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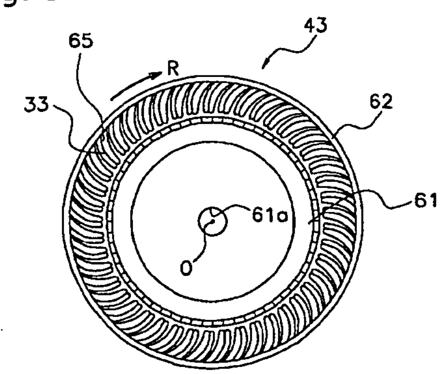
(54) **IMPELLER FOR MULTIBLADE BLOWER, AND MULTIBLADE BLOWER HAVING THE SAME**

(57) The present invention provides an impeller that is capable of reducing the noise caused by turbulent vortices produced near the main plate of the impeller, and provides a low noise multi-blade fan. A multi-blade fan (40) is primarily composed of an impeller (63), a casing (11) that covers the impeller (63), and a motor (14) that rotates the impeller (43). The impeller (43) includes a disk-shaped main plate (61) to which a plurality of blades (33) are fixed to the outer peripheral edge thereof, and an annular side plate (62) to which the other ends of the plurality of blades (33) are connected. Furthermore, inter-blade portions (65) located between the plurality of blades (33) are cut out from the main plate (61) on the front sides in the rotational direction of the plurality of blades (33). The plurality of inter-blade portions (65) are larger in the circumferential direction than the thickness in the circumferential direction of the blades (33), and are cut out on the front side in the rotational direction of the blades (33) with a length that does not reach the rear side in the rotational direction of the adjacent blades (33). In addition, the inter-blade portions (65) are cut out in the radial direction along the shape of the blades (33) at a length that extends from the outer peripheral edge of the blades (33) to the inner peripheral edge of the blades (33).

Fig. 6



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Description

TECHNICAL FIELD

[0001] The present invention relates to an impeller for a multi-blade fan and a multi-blade fan equipped with the same. More particularly, the present invention relates to an impeller for a multi-blade fan in which the ends of a plurality of blades that extend from a main plate are connected by means of an annular side plate, and to a multi-blade fan equipped with the same.

BACKGROUND ART

[0002] A multi-blade fan is employed in devices such as air purifiers, air conditioners, and the like (hereinafter referred to as "air conditioners") in order to blow air. A conventional multi-blade fan is shown in Figs. 1-3. Fig. 1 shows lateral cross-sectional views of a conventional multi-blade fan, Fig. 2 shows a perspective view of an impeller for the conventional multi-blade fan, and Fig. 3 shows a plan view of the impeller for the conventional multi-blade fan.

[0003] The multi-blade fan 10 includes an impeller 13, a casing 11 that covers the impeller 13, and a motor 14 that rotates the impeller 13. The impeller 13 includes a disk-shaped main plate 31 to which one end of each of a plurality of blades 33 are fixed to the outer peripheral edge thereof, and an annular side plate 32 to which the other ends of the blades 33 are connected. An air discharge port 11a, and an air intake port 11b that is surrounded by a bell mouth 12, are formed in a casing 11. The intake port 11b faces the side plate 32 of the impeller 13. In addition, the discharge port 11 a is formed in a direction that is perpendicular to the intake port 11b so that air is blown out in a direction approximately perpendicular to a rotational axis O-O of the impeller 13.

[0004] When the motor 14 rotates to operate the multi-blade fan 10, the impeller 13 rotates in a rotational direction R (shown in Fig. 3) with respect to the casing 11. This allows each blade 33 of the impeller to scoop out air from the inner peripheral side of the impeller 13 to a space on the outer peripheral side thereof, draw in air from the intake port 11b into the inner peripheral space of the impeller 13, and blow the air that was pushed out to the outer peripheral side of the impeller 13 through the discharge port 11a. In other words, the multi-blade fan 10 draws in air from the intake port 11b and blows air out from the discharge port 11a.

[0005] Noise is produced in this type of multi-blade fan 10 that is caused by turbulent vortices produced near the main plate 31. More specifically, the turbulent vortices are generated by the mechanism described below.

[0006] As shown in Fig. 1(a), air drawn into the interior of the impeller 13 from the intake port 11b mainly flows toward the main plate 31 and then gradually toward the outer periphery (see air flow W). However, as shown in Fig. 1(b), a portion of the air drawn in from the intake port 11b collides with the main plate 31, and then flows toward the outer peripheral side near the main plate 31 (see air flow X). Turbulent vortices are generated in this air flow X due to the collision with the main plate 31. The turbulent vortices flow with the air flow X toward the outer periphery and further merge with the air flow that collides with the main plate 31, and thus the turbulent vortices in the air flow X then gradually grow and the biggest turbulent vortices are formed on the inner peripheral edges of the blades 33. These enlarged turbulent vortices are scooped out toward the outer periphery by the blades 33, and this generates noise.

[0007] In addition, when a reduction in manufacturing costs is important, the cross-sectional shapes of the blades in the aforementioned fan are designed to be approximately the same in each position so that the blades can be unitarily formed from a synthetic resin by means of a two-piece horizontal mold. In other words, the blades are not slanted or curved so that they can be formed with only upper and lower molds (see blades 33 in Figs. 2 and 3). However, this type of blade shape creates a state in which the amount of air that flows in and out of will be different at each blade position, and this causes noise to be generated. Taking measures such as slanting the blades at proper positions is one way of reducing this type of noise, however doing so will place the blades into shapes that cannot be unitarily formed by means of upper and lower molds and thus greatly increase the cost of manufacturing the impeller. In other words, it will be necessary to use a slide mold in order to form the slanted portions of the blades, and this will increase the number of molds, increase the cost of manufacturing, and lengthen the time it will take to form the blades.

DISCLOSURE OF THE INVENTION

[0008] An object of the present invention is to provide an impeller that is capable of reducing the noise caused by turbulent vortices produced near the main plate of the impeller, and to provide a low noise multi-blade fan.

[0009] The impeller of a multi-blade fan disclosed in claim 1 includes a main plate that rotates about a rotational axis, a plurality of blades that are annularly disposed about the rotational axis with one end of the plurality of blades fixed to the main plate, and an annular side plate that connects with the other end of the plurality of blades. Then, inter-blade portions positioned between the plurality of blades of the main plate are cut out on at least the front sides of the blades in the rotational direction.

[0010] With this impeller for a multi-blade fan, a portion of the turbulent vortices that grew due to the collision of the air flow with the main plate and the merger with the air flow will travel from the inter-blade portions of the main plate positioned between the plurality of blades toward the exterior of the main plate in the axial direction

immediately before being scooped out by the blades because the cut out inter-blade portions are at least cut out in the front of the blades in the rotational direction. This allows the noise generated when the air flow is scooped out by the blades to be reduced.

[0011] The impeller for a multi-blade fan disclosed in claim 2 is the impeller of claim 1, in which the side plate has an inner diameter that is larger than the outer diameter of the main plate. Then, inter-blade portions positioned between the plurality of blades of the main plate are cut out larger than the outer dimensions of the blades.

[0012] Here, by cutting out the inter-blade portions from a conventional main plate that was not cut out, the blades of one impeller can be inserted into the inter-blade portions of another impeller and at least two impellers can thereby be stacked together. When stacked together, side plates having an inner diameter that is larger than the outer diameter of the main plates will not be damaged, and two impellers can be stacked together if the blades of one impeller can be passed through the cut-outs of the inter-blade portions of the main plate on another impeller. Then, two impellers can be stacked together because cut-outs that are larger than the outer dimensions of the blades are formed in the inter-blade portions. In this way, when two impellers are stacked together, space efficiency will be improved to twice that of the prior art. In addition, if large inter-blade portions are present and cut-outs in which two blades can pass through are formed in the inter-blade portions, three impellers can be stacked together and space efficiency can be improved to three times that of the prior art.

[0013] Up until now, no one has ever attempted to cut out inter-blade portions from the main plate as described above because it was felt that this would reduce the capabilities of a multi-blade fan. However, the inventors of the present invention reevaluated the impeller from a variety of viewpoints, and found that there was almost no reduction in the capabilities (efficiency and noisiness) of the fan even if the cut-outs were provided in the inter-blade portions of the main plate as described above. The impeller according to the present claim was created based upon this discovery, and this impeller is compatible with both maintaining fan capabilities and improving the transportation thereof.

[0014] Note that in situations in which there are no problems with impeller strength and it is acceptable for the capabilities of the impeller to be slightly reduced, the entire inter-blade portion of the main plate may be cut out, rather than just a portion thereof, in order to maximize space efficiency.

[0015] The impeller for a multi-blade fan disclosed in claim 3 is the impeller of claims 1 or 2, in which the inter-blade portions are partially cut out in the circumferential direction.

[0016] With this multi-blade fan impeller, the inter-blade portions are at least partially cut out from the main plate in the circumferential direction and from the front of the blades in the rotational direction, and are not cut out up to the rear side of the inter-blade portions in the rotational direction.

[0017] In addition, although it is effective to cut out the rear sides of the inter-blade portions in the rotational direction in order for the air flow and the turbulent vortices to flow from the rear sides in the rotational direction toward the exterior of the main plate in the axial direction and escape the impeller, the air flow will break away from the blades to a large degree because the rear sides of the inter-blade portions in the rotational direction are negative pressure surfaces. Thus, the air flow will break away and thus the noise reduction effect may decline. Therefore, with this multi-blade fan impeller, there will not be a large increase in the break away of the air flow because the rear sides of the inter-blade portions are not cut out. In this way, there will be no damage to the noise reduction effect produced by the cut-outs on the front side of the inter-blade portions in the rotational direction.

[0018] The multi-blade fan impeller disclosed in claim 4 is the impeller of any of claims 1 to 3, in which the inter-blade portions are cut out from the outer peripheral edges of the blades to the inner peripheral edges thereof.

[0019] With this multi-blade fan impeller, the turbulent vortices easily escape from the cut out inter-blade portions before they reach the outer peripheral edges of the blades because the inter-blade portions are cut out from the outer peripheral edges of the blades to the inner peripheral edges thereof. In this way, the turbulent vortices that arrive at the outer peripheral edges of the blades can be further diminished, and noise can be further reduced.

[0020] The multi-blade fan impeller disclosed in claim 5 is the impeller in any of claims 1 to 4, in which the plurality of blades include slanted portions that each slant forward in the rotational direction. With the inter-blade portions, at least the projecting portions of the slanted portions of each blade are cut out therefrom.

[0021] Here, because slanted portions are provided on the plurality of blades, differences in the volume of air that flows into and out from the impeller at each position of the blades can be controlled to a low level, and both improvement in fan efficiency and a reduction in noise can be easily provided. In addition, providing a slanted portion on each blade and cutting out the main plate will eliminate interference (the main plate) from the projecting portions of the slanted portions. Because of this, the plurality of blades included on the main plate can be unitarily formed from a synthetic resin material by means of a pair of molds. In other words, blades that include slanted portions that could not be unitarily formed in the prior art can now be formed by means of a mold that is inserted from the cut-out portions (inter-blade portions) of the main plate and which forms the inner surfaces of the slanted portions, and a mold that forms the outer surfaces of the slanted portions from the

opposite sides. In other words, this impeller can both reduce noise and be unitarily formed from a synthetic resin.

[0022] The multi-blade fan impeller disclosed in claim 6 is the impeller of claim 5, in which the entire portion of each of the plurality of blades are slanted.

[0023] Here, because the entire portion of each of the blades are slanted and the entire portion of each of the blades is the slanted portion, almost the entire air flow can be uniformly changed.

[0024] The multi-blade fan disclosed in claim 7 includes the impeller set forth in any of claims 1 to 6, a drive means that rotates the main plate, and a casing that covers the impeller and which includes an intake port that faces an opening in an inner peripheral side of the side plate and a discharge port that is provided on an outer peripheral side of the impeller and which blows air in a direction approximately perpendicular to the rotational axis.

[0025] With this multi-blade fan, the impeller rotates with respect to the casing when the main plate is rotated by the drive means. When this occurs, each blade of the impeller scoops out air from the inner peripheral side of the impeller to a space on the outer peripheral side thereof, draws in air from the intake port into the inner peripheral space of the impeller, and blows the air that was pushed out to the outer peripheral side of the impeller through the discharge port. In other words, the multi-blade fan draws in air from the intake port and blows out air from the discharge port.

[0026] When this occurs, because the impeller disclosed in any of claims 1 to 6 is employed the turbulent vortices produced by the collision of the air flow with the main plate and the merger with the air flow can escape from the cut out inter-blade portions in the main plate. In this way, the turbulent vortices that arrive at the outer peripheral edges of the blades can be diminished, and noise can be further reduced.

BRIEF DESCRIPTION OF THE DRAWINGS

[0027]

Fig. 1(a) is a lateral view of a conventional multi-blade fan (casing portion is a cross-sectional view).
Fig. 1(b) is a lateral view of the conventional multi-blade fan, and describes a mechanism by which noise is generated near a main plate (a portion of an impeller shown in cross-section).
Fig. 1(c) is a lateral view of the conventional multi-blade fan, and describes a mechanism by which noise is generated near a side plate (a portion of the impeller shown in cross-section).
Fig. 2 is a perspective view of the impeller of the conventional multi-blade fan.
Fig. 3 is a plan view of the impeller of the conventional multi-blade fan.
Fig. 4 is a lateral view of a multi-blade fan of a first embodiment (casing portion is a cross-sectional view).
Fig. 5 is a lateral view of an impeller of the multi-blade fan of the first embodiment (one portion is a cross-sectional view).
Fig. 6 is a plan view of the impeller of the multi-blade fan of the first embodiment.
Fig. 7(a) is an enlarged view of wave form members (triangular wave forms).
Fig. 7(b) is an enlarged view of wave form members (sine wave forms).
Fig. 7(c) is an enlarged view of wave form members (rectangular wave forms).
Fig. 8(a) is a lateral view of the multi-blade fan of the first embodiment, and describes the noise reduction effect of the wave form members formed on the main plate (a portion of the impeller shown in cross-section).
Fig. 8(b) is a lateral view of the multi-blade fan of the first embodiment, and describes the noise reduction effect of the wave form members formed on the side plate.
Fig. 8(c) is a lateral view of the multi-blade fan of the first embodiment, and describes the noise reduction effect of inter-blade cut-out portions on the main plate (a portion of the impeller shown in cross-section).
Fig. 9 is a front view of an impeller according to a second embodiment of the present invention.
Fig. 10(a) is a lateral view of the impeller of the second embodiment.
Fig. 10(b) is the b-b cross-sectional view.
Fig. 11(a) is a lateral view showing impellers of the second embodiment in a stacked state.
Fig. 11(b) is a lateral view showing conventional impellers placed on top of each other.
Fig. 12 is a front view of an impeller according to a third embodiment of the present invention.
Fig. 13(a) is a lateral view of the impeller of the third embodiment.
Fig. 13(b) is the b-b cross-sectional view.
Fig. 14 is an upper view of an impeller according to a fourth embodiment of the present invention.
Fig. 15 is a lateral view of an impeller.
Fig. 16 is a cross-sectional view taken along line VI-VI of Fig. 15.
Fig. 17 is an enlarged partial view taken along line VII of Fig. 14.
Fig. 18 is a cross-sectional view taken along line VIII-VIII of Fig. 17.
Fig. 19 is a cross-sectional view of a mold with the cross-section of Fig. 18.
Fig. 20 is a vertical cross-sectional view of a modified example (A) of the blades.
Fig. 21 is a vertical cross-sectional view of a modified example (B) of the blades.
Fig. 22 is a vertical cross-sectional view of a modified example (C) of the blades.

Fig. 23 is an enlarged upper view of a modified example (D) of the blades.

Fig. 24 is an enlarged upper view of another modified example (D) of the blades.

Fig. 25 is an enlarged upper view of a modified example (E) of the blades.

BEST MODE FOR CARRYING OUT THE INVENTION

First Embodiment

(1) Configuration of the multi-blade fan

[0028] A multi-blade fan (centrifugal fan) according to an embodiment of the present invention differs from the conventional multi-blade fan 10 shown in Figs. 1 to 3 in that the impeller 13 includes jagged shaped wave form members on the main plate 31 near the inner peripheral edges of the plurality of blades, jagged shaped wave form members on the main plate 31 side of the side plate 32, and a plurality of inter-blade cut-out portions 35 that have been cut out from the main plate 31 on the front side in the rotational direction of the blades 33.

[0029] Fig. 4 shows a lateral cross-sectional view of a multi-blade fan 40 of the present embodiment, and Figs. 5 and 6 show a lateral cross-sectional view and a plan view of an impeller 43 of the multi-blade fan 40.

[0030] The multi-blade fan 40 is primarily composed of an impeller 63, a casing 11 that covers the impeller 63, and a motor 14 that rotates the impeller 43.

[0031] The impeller 43 includes a disk-shaped main plate 61 to which a plurality of blades 33 are fixed to the outer peripheral edge thereof, and an annular side plate 62 to which the other ends of the plurality of blades 33 are connected. A detailed description of the impeller 43 will be provided below.

[0032] An air discharge port 11a, and an air intake port 11b that is surrounded by a bell mouth 12, are formed in the casing 11. The intake port 11b faces the side plate 62 of the impeller 43. Air that flows through the intake port 11b and into the space in the interior of the impeller 43 generally flows along the rotational axis O-O of the impeller 43 when it enters this space, and then flows in a direction away from the rotational axis O-O (toward the outer periphery of the impeller 43) due to the rotation of the impeller 43. In addition, the discharge port 11a is formed such that it is perpendicular to the intake port 11b, so that air is blown out in a direction approximately perpendicular to the rotational axis O-O of the impeller 43.

[0033] A rotation shaft of the motor 14 is mounted in a central hole 61 a in the main plate 61 (see Fig. 6), and rotates the impeller 43 by rotating the main plate 61. The main portion of the motor 14 is fixed to the casing 11.

[0034] The impeller 43 will now be described.

[0035] As shown in Figs. 5 and 6, the impeller 43 includes the main plate 61, the plurality of blades 33, and the annular side plate 62. In the present embodiment, the impeller 43 is a product made of a synthetic resin in which a mold is used to unitarily form the main plate 61, the plurality of blades 33, and the side plate 62 together.

[0036] As shown in Fig. 6, the main plate 61 is a disk-shaped member in which the central hole 61a is formed, and the rotation shaft of the motor 14 is fixed in the central hole 61a.

[0037] The plurality of blades 33 (described below) are formed around the outer peripheral edge of the main plate 61 and are equidistant with respect to each other in the rotational direction. Jagged shaped wave form members 64 are formed around a circumference of the main plate 61 near the inner peripheral edges of the plurality of blades 33. Here, the wave form members 64 include triangular wave forms that have a wave pitch P of 3 mm and a wave height H of 2 mm (see Fig. 7(a)). Note that the wave form members are not limited to triangular wave forms, and as shown in Figs. 7(b) and 7 (c), may have wave forms shaped like sine waves or rectangles. In addition, the dimensions of the wave form members are not limited to those of the present embodiment, and the wave pitch P may be in a range between 2 mm and 8 mm, and the wave height H may be in a range between 1 mm and 5 mm.

[0038] Furthermore, inter-blade portions 65 located between the plurality of blades 33 are cut out from the main plate 61 on the front sides in the rotational direction of the plurality of blades 33. The plurality of inter-blade portions 65 are larger in the circumferential direction than the thickness in the circumferential direction of the blades 33, and are cut out on the front side in the rotational direction of the blade 33 with a length that does not reach the rear side in the rotational direction of the adjacent other blades 33. In addition, the inter-blade portions 65 are cut out in the radial direction along the shape of the blades 33 at a length that extends from the outer peripheral edge of the blades 33 to the inner peripheral edge of the blades 33.

[0039] The blades 33 include a recessed surface on the front sides thereof in the rotational direction, and these members are annularly disposed with the rotational axis O-O at the center thereof. One end of the blades 33 are fixed to the outer peripheral edge of the main plate 61, and extend lengthwise from this point along the rotational axis O-O without twisting. Then, as shown in Figs. 5 and 6, the other end of the blades 33 are connected to the annular side plate 62.

[0040] The annular side plate 62 is disposed on the outer peripheral side of the other ends of the blades 33, and is connected to each blade 33. The side plate 62 is unitarily formed together with the main plate 61 and the plurality of blades 33. The jagged shaped wave form members 66 are formed on the main plate 61 side of the side plate 62. Here, like the wave form members 64 on the main plate 61, the wave form members 66 includes triangular wave forms that have a wave pitch P of 3 mm and a wave height H of 2 mm (see Fig. 7(a)). Note that the wave form members are not limited to triangular

wave forms, and as shown in Figs. 7(b) and 7(c), may have wave forms shaped like sine waves or rectangles. In addition, the dimensions of the wave form members are not limited to those of the present embodiment, and the wave pitch P may be in a range between 2 mm and 8 mm, and the wave height H may be in a range between 1 mm and 5 mm.

(2) Operation of the multi-blade fan

[0041] When the motor 14 rotates to operate the multi-blade fan 40, the impeller 43 rotates in a rotational direction R (shown in Fig. 6) with respect to the casing 11. In other words, air will be scooped out primarily by the recessed surface on the front side in the rotational direction of the blades 33 of the multi-blade fan 40. This allows the blades 33 of the impeller 43 to scoop out air from the inner peripheral side of the impeller 43 to a space on the outer peripheral side thereof, draw in air from the intake port 11b into the inner peripheral space of the impeller 43, and accumulate and blow the air that was scooped out to the outer peripheral side of the impeller 43 and out the discharge port 11a (see air flow Z in Fig. 4). In other words, the multi-blade fan 40 draws in air from the intake port 11b along the rotational axis O-O, and the air is then blown out from the discharge port 11a in a direction that is perpendicular to the rotational axis O-O. Note that although only the air flow Z on the right side of the rotational shaft O-O is shown in Fig. 4, the air scooped out to the outer peripheral side of the impeller 13 on the left side of the rotational axis O-O will flow along the casing 11 to the discharge port 11a and then be blown out.

(3) Transporting the impeller

[0042] When the impeller 43 is to be transported, a plurality of impellers 43 are stacked along the rotational axis O-O.

[0043] Here, as noted above, the inter-blade portions 65 on the main plate 61 of the impeller 43 of the present embodiment are larger in the circumferential direction that the thickness in the circumferential direction of the blades 33, and the inter-blade portions 65 are cut out to a length that extend from the outer peripheral edge of the blades 33 to the inner peripheral edges of the blades 33 along the curved shape of the blades 33. The inter-blade portions 65 are used to stack two impellers 43 along the rotational axis O-O. The blades 33 on one impeller 43 can be fit into the corresponding plurality of inter-blade portions 65 on another impeller 43. Two impellers 43 fit together in this way can be stacked together to a predetermined height and then transported.

(4) Example

[0044] The results of an experiment in which sound measurements taken from a multi-blade fan in which the impeller of the present embodiment was used will now be described.

[0045] The present experiment is one in which sound measurements were taken from the conventional example shown in Figs. 2 and 3 and the present embodiment shown in Figs. 5 and 6. Note that in the present embodiment, the wave form members 64 formed on the main plate 61, the wave form members 66 formed on the side plate 62, and the inter-blade portions 65 on the main plate 61 are simultaneously formed in order to reduce noise. Accordingly, in order to confirm the sound reduction effects of these three elements, impellers having only one of each of these three elements were prepared and a sound reduction experiment was conducted on each impeller. The results of these sound reduction experiments are shown below.

1. An impeller in which only the wave form members 64 were formed on the main plate 61

[0046] There was a 0.8 dB reduction in noise compared to the conventional example.

2. An impeller in which only the wave form members 66 were formed on the side plate 62

[0047] There was a 0.5 dB reduction in noise compared to the conventional example.

3. An impeller having only the inter-blade portions 65 on the main plate 61

[0048] There was a 0.5 dB reduction in noise compared to the conventional example.

[0049] The aforementioned results confirm that there is a reduction in noise in the present embodiment when any of the three elements are adopted with the goal of reducing noise.

(5) Special characteristics of the multi-blade fan

[0050] The special characteristics of the multi-blade fan of the present embodiment are as follows.

1. Reduction in noise due to the wave form members formed on the main plate of the impeller

[0051] In the conventional multi-blade fan 10, noise is produced by turbulent vortices generated near the main plate 31. More specifically, the turbulent vortices are generated by the mechanism described below.

[0052] As shown in Fig. 1(b), a portion of the air drawn in from the intake port 11b collides with the main plate 31 in the interior of the impeller 13, and then flows near the main plate 31 toward the outer peripheral side (see air flow X). Turbulent vortices are generated in this air flow X due to the collision with the main plate 31. The turbulent vortices flow with the air flow X toward the out-

er periphery and further merge with the air flow that collides with the main plate 31. The turbulent vortices in the air flow X then gradually grow, and the biggest turbulent vortices are formed on the inner peripheral edges of the blades 33. These enlarged turbulent vortices are scooped out toward the outer periphery by the blades 33, and this generates noise.

[0053] On the other hand, as shown in Fig. 8, with the impeller 43 of the multi-blade fan 40 of the present embodiment, the turbulent vortices that grew due to the collision of the air flow Z1 with the main plate 61 and the merger with the air flow will be reduced in size immediately before reaching the blades 33 because the wave form members 64 are formed on at least the side plate 62 side of the main plate 61 near the inner peripheral edges of the blades 33. This allows the noise generated when the air flow Z1 is scooped out by the blades 33 to be reduced.

2. Reduction in noise due to the wave form members formed on the side plate of the impeller

[0054] In the conventional multi-blade fan 10, swirling vortices are produced in which the centers thereof are near the outer peripheral edge of the side plate 32. The swirling vortices do not assist the impeller 13 to blow air, and thus as a result, the swirling vortices cause noise and reduced fan efficiency. More specifically, the turbulent vortices are generated by the mechanism described below.

[0055] As shown in Fig. 1(c), a portion of the air inside the casing 11 is scooped out to the outer periphery of the impeller 13, and then swirling vortices Y are produced near the side plate 32 such that air is again drawn in from near the bell mouth 12 of the impeller 13 to the inner peripheral side of the impeller 13. Because of this, a portion of the air cannot be effectively blown, and this portion corresponds to a ratio b/B (hereinafter referred to as blockage factor BF) between a length b in the axial direction of the portion of the impeller 13 that produces the swirling vortices Y and a length B in the axial direction of the entire impeller 13. Because of this, there will be a reduction in fan efficiency and noise will be generated.

[0056] On the other hand, with the impeller 43 of the multi-blade fan 40 of the present embodiment, the pressure fluctuations near the impeller 43 exit of the side plate 62 will be reduced because the wave form members 66 are formed on the main plate 61 side of the side plate 62 surface. When this is done, as shown in Fig. 8 (b), it will become difficult for the air flow scooped out by the impeller 43 on the exit side to be again drawn into the inner peripheral side of the impeller 43 from the side plate 62 side in the rotational direction of the impeller 43, and thus the swirling vortices Z2 produced near the side plate 62 will be reduced. This allows fan efficiency to improve and noise to be reduced because the B_F value will be reduced to b1/B1 and the portion of the impeller 43 that can effectively blow air will be enlarged.

3. Noise reduction due to the inter-blade portions on the main plate of the impeller

[0057] With the impeller 43 of the multi-blade fan 40 of the present embodiment, as shown in Fig. 8(c), because the inter-blade portions 65 positioned between the plurality of blades 33 of the main plate 61 are at least cut out from the front side in the rotational direction, a portion of the turbulent vortices that grew due to the collision of the air flow Z3 with the main plate 61 and the merger with the air flow are allowed to travel from the cut-out inter-blade portions 65 toward the exterior of the main plate 61 in the axial direction immediately before they are scooped out by the blades 33. Like the wave form members 64 formed on the main plate 61 shown in Fig. 8(a), this allows a reduction in the noise generated when the air flow is scooped out by the blades 33.

[0058] In addition, the inter-blade portions 65 of the impeller 43 of the present embodiment are partially cut out from the front side in the rotational direction of the main plate 61, and are not cut out up to the rear side in the rotational direction of the inter-blade portions 65. Thus, there will be no increase in air flow breakaway on the rear sides in the rotational direction of the inter-blade portions 65. In this way, there will be no damage to the noise reduction effect produced by the cut-outs on the front side in the rotational direction of the inter-blade portions 65.

[0059] Furthermore, the turbulent vortices of the air flow Z3 easily escape from the cut-out inter-blade portions 65 before they arrive at the outer peripheral edges of the blades 33 because the inter-blade portions 65 of the impeller 43 of the present embodiment are cut out from the outer peripheral edges of the blades 33 to the inner peripheral edges thereof. In this way, the turbulent vortices that arrive at the outer peripheral edges of the blades 33 can be further diminished, and noise can be further reduced.

4. Increase in load efficiency when transporting impellers

[0060] As noted above, the inter-blade portions 65 of the main plate 61 of the impeller 43 of the present embodiment are larger in the circumferential direction that the thickness in the circumferential direction of the blades 33, and the inter-blade portions 65 are cut out to a length that extends from the outer peripheral edges of the blades 33 to the inner peripheral edges of the blades 33 along the curved shape of the blades 33. This shape is used to stack two impellers 43 from the rotational axis O-O, and the blades 33 can be respectively fit into the cut-outs of the plurality of inter-blade portions 65. In this way, the load efficiency when loading the impellers 43 can be improved.

[Second Embodiment]

(Configuration of the multi-blade fan)

[0061] A multi-blade fan according to a second embodiment of the present invention substitutes an impeller 113 shown in Figs. 9 and 10 for the impeller 13 of the conventional multi-blade fan 10 shown in Figs. 1 - 3.

[0062] The impeller 113 is a synthetic resin article that is formed by molding, and includes a main plate 131, a side plate 132, and a plurality of blades 133. The main plate 131 is round, and is rotated about the rotational axis O-O (see Fig. 1) by means of a motor 14. A central hole 131a is provided in the main plate 131, and a rotation shaft of the motor 14 is mounted in the central hole 131a. The plurality of blades 133 are annularly disposed around the rotational axis O-O, and extend along the rotational axis O-O. One end of each blade 133 is fixed to outer peripheral portions of the main plate 131. The side plate 132 is an annular member, and has an inner diameter that is either the same as or slightly larger than an outer diameter of the main plate 131. The outer peripheral edges of the other ends of the plurality of blades 133 are connected to the side plate 132.

[0063] As shown in Fig. 10(b), cut-outs 131b are formed in portions hereinafter referred to as inter-blade portions between adjacent blades 133 on the main plate 131. The cut-outs 131b extend from the outer peripheral edge of the main plate 131 to a position near the inner peripheral edges of the blades 133 in the radial direction. More specifically, the cut-outs 131b extend from the outer peripheral edge of the main plate 131 to a point slightly inside the inner peripheral edges of the blades 133. In addition, the widths of the cut-outs 131b in the circumferential direction are larger than the largest width in the circumferential direction of the blades 133. In other words, the inter-blade portions of the main plate 131 are cut to be larger than the outer cross-sectional dimensions of the blades 133.

[0064] Other than the cut-outs 131b, the inter-blade portions of the main plate 131 also include front blade plate portions 131c and rear blade plate portions 131d. The front blade plate portions 131c are outer peripheral portions of the main plate 131 that extend from the bases of the blades 133 to the front sides thereof in the rotational direction. The rear blade plate portions 131d are outer peripheral portions of the main plate 131 that extend from the bases of the blades 133 to the rear sides thereof in the rotational direction.

[0065] As shown in Fig. 1, an air discharge port 11a, and an air intake port 11b that is surrounded by a bell mouth 12, are formed in a casing 11. The intake port 11b faces the side plate 132 of the impeller 113. In addition, the discharge port 11a is formed such that it is perpendicular to the intake port 11b, so that air is blown out in a direction approximately perpendicular to the rotational axis O-O of the impeller 113.

(Special characteristics of the multi-blade fan and impeller)

[0066]

1. With the impeller 113 of the present embodiment, as shown in Fig. 11(a), two impellers 113, 113 can be stacked together by cutting out inter-blade portions from a conventional uncut main plate 131 such that the blades 133 on one impeller 113 are inserted between the blades 133 of another impeller 113. When stacked together, side plates 132 having inner diameters that are larger than the outer diameters of main plates 131 will not be damaged, and two impellers 113, 113 can be stacked together by passing the blades 133 of one impeller 113 through the cut-outs 131b of the inter-blade portions of the main plate 131 on another impeller 113. This stacking is achieved by forming the cut-outs 131b in the inter-blade portions of the main plate 131 to be larger than the cross-sectional shapes of the blades 133.

   As shown in Fig. 11(b), this allows the space utilization to be improved to approximately twice that when two conventional impellers 13', 13' are stacked on top of each other. In addition, if the cut-outs 131b are of a size that allows two blades 133 to pass therethrough, then three impellers can be stacked together and space utilization can be improved to approximately three times that of the prior art.

2. Up until now, no one has ever attempted to cut out inter-blade portions from the main plate 131 as described above because it was felt that this would reduce the capabilities of a multi-blade fan. However, after looking at the impeller from a variety of viewpoints and conducting experiments, it was confirmed that providing the cut-outs 131b in the inter-blade portions of the main plate 131 did not reduce the capabilities (efficiency and noisiness) of the fan.

   The reason why there is no reduction in the capabilities of a multi-blade fan even if these types of cut-outs 131b are present is presumed to be as follows.

   The air flow in the multi-blade fan includes air flow that is drawn in from the intake port 11b to the space in the inner peripheral side of the impeller 113, and which then collides with the main plate 131 and flows toward the outer periphery thereof. This air flow includes turbulent vortices that are generated and grown by the merger of the air flow that collides with the main plate 131 and another air flow. Then, the turbulent vortices generate sound when the air on the outer peripheral side of the impeller 113 is scooped out by the blades 133. However, because the cut-outs 131b are provided in the inter-blade portions of the main plate 131, the turbulent vortices pass through the cut-outs 131b in the di-

rection of the rotational axis O-O immediately before they are scooped out by the blades 133. Because of this, it is thought that noise will be reduced compared to conventional impellers that do not have the cut-outs 131. Even if there is a reduction in capabilities due to the presence of the cut-outs 131b, the cut-outs 131b compensate for this by playing a role in reducing noise.

3. In the impeller 113 of the present embodiment, the inter-blade portions of the main plate 131 are cut out from approximately the inner peripheral ends of the blades 133 in the radial direction to the outer peripheral sides thereof (see Fig. 10(b)). Thus, it is thought that air drawn from the intake port 11b to the space in the inner peripheral side of the impeller 113 will be prevented from unnecessarily flowing to the rear side of the main plate 131, and a reduction in fan efficiency will not be seen.

4. The multi-blade fan of the present embodiment can employ an impeller 113 that has good space efficiency when being transported and no reduced capabilities, and thus the capabilities of the multi-blade fan can be maintained while reducing the manufacturing costs thereof.

[Third Embodiment]

[0067] With the impeller 113 of the second embodiment, the cut-outs 131b of the inter-blade portions of the main plate 131 are formed in the portions between the blades 133. However, as shown in Figs. 12 and 13, if the strength of the impeller is not a problem then it is preferable to place the cut-outs on the front sides of the blades in the rotational direction.

(Configuration of the impeller)

[0068] In the present embodiment, an impeller 213 shown in Figs. 12 and 13 is employed instead of the impeller 113 of the second embodiment. The impeller 213 includes a main plate 231, a side plate 132, and a plurality of blades 133. The main plate 231 is round, and is rotated about the rotational axis O-O (see Fig. 1) by means of a motor 14. A central hole 231a is provided in the main plate 231, and a rotation shaft of the motor 14 is mounted in the central hole 231a. The plurality of blades 133 are annularly disposed around the rotational axis O-O, and extend along the rotational axis O-O. One end of each blade 133 is fixed to outer peripheral portions of the main plate 231. The side plate 132 is an annular member, and has an inner diameter that is either the same as or slightly larger than an outer diameter of the main plate 231. The outer peripheral edges of the other ends of the plurality of blades 133 are connected to the side plate 132.

[0069] As shown in Fig. 13(b), cut-outs 231b are formed in portions hereinafter referred to as inter-blade portions between adjacent blades 133 on the main plate 231. The cut-outs 231b extend from the outer peripheral edge of the main plate 231 to a position near the inner peripheral edges of the blades 133 in the radial direction. More specifically, the cut-outs 231b extend from the outer peripheral edge of the main plate 231 to a point slightly inside the inner peripheral edges of the blades 133. In addition, the widths of the cut-outs 231b in the circumferential direction are larger than the largest width in the circumferential direction of the blades 133. In other words, the inter-blade portions of the main plate 231 are cut to be larger than the outer cross-sectional dimensions of the blades 133.

[0070] Furthermore, the cut-outs 231b are cut out from the bases on the front sides of the blades 133 in the rotational direction, and there are no plates between the blades and the cut-outs 231b. In other words, only rear blade plate portions 231d that extend from the bases of the blades 133 rearward in the rotational direction are present in the inter-blade portions of the main plate 231 (see Fig. 13(b)).

(Special characteristics of the impeller)

[0071] With the impeller 213 of the present invention, the cut-outs 231b are provided in the front portions of the blades 133 in the rotational direction. By cutting out the inter-blade portions in this way, the impeller 213 will not only maintain its capabilities with respect to situations in which the inter-blade portions are cut out, but will in fact improve its capabilities. This could not be imagined with a prior art impeller, but for the following reasons it is thought that noise will be reduced and the capabilities of the multi-blade fan will improve.

[0072] First, like with the aforementioned second embodiment, the cut-outs 231b are provided in the inter-blade portions of the main plate 231, and thus it is presumed that the turbulent vortices pass through the cut-outs 231b in the direction of the rotational axis O-O immediately before they are scooped out by the blades 133, and that noise will be reduced when compared to conventional impellers that do not have the cut-outs 231b.

[0073] Furthermore, in the present embodiment, the inter-blade portions of the main plate 231 of the impeller 213 are cut out from the bases of the blades 133 forward in the rotational direction, and thus the width in the circumferential direction of the rear blade plate portions 231d can be sufficiently maintained, and tendency for the air flow to break away from the blades 133 rearward in the rotational direction can be more effectively controlled. Because of this, it is presumed that this impeller reduces noise more than with the impeller of the second embodiment.

[Fourth Embodiment]

(1) Configuration of the centrifugal fan

[0074] A sirocco fan according to an embodiment of the present invention substitutes an impeller 1113 shown in Figs. 14 and 15 for the impeller 13 of the conventional multi-blade fan 10 shown in Figs. 1-3.

(2) Configuration of the impeller

[0075] The impeller 1113 is a synthetic resin article that is unitarily formed by molding a synthetic resin material, and includes a main plate 1131, a side plate 1132, and a plurality of blades 1133. The main plate 1131 is round, and is rotated about the rotational axis O-O (see Fig. 1) by means of a motor 14. A central hole 1131a is provided in the main plate 1131, and a rotation shaft of the motor 14 is mounted in the central hole 1131a. The plurality of blades 1133 are annularly disposed around the rotational axis O-O, and extend along the rotational axis O-O. One end of each blade 1133 is fixed to outer peripheral portions of the main plate 1131. The side plate 1132 is an annular member, and has an inner diameter that is either the same as or slightly larger than an outer diameter of the main plate 1131. The outer peripheral edges of the other ends of the plurality of blades 1133 are connected to the side plate 1132.

[0076] As shown in Figs. 14, 15, 17 and 18, the plurality of blades 1133 that extend from the main plate 1131 along the rotational axis O-O are curved forward in the rotational direction along their lengths, and the tips (other ends) of the blades 1133 are connected to the side plate 1132. Thus, as shown in Fig. 18, the blades 1133 include main portions 1133a on the main plate 1131 side, and slanted portions 1133b on the side plate 1132 side.

[0077] In addition, with the main plate 1131, projecting portions which are the slanted portions 1133b of the blades 1133 that project toward the main plate 1131 along the rotational axis O-O are cut out therefrom. In this way, the cut-outs 1131b are formed in the main plate 1131 between adjacent blades 1133. As shown in Fig. 16, these cut-outs 1131b have shapes that reach the outer peripheral edge of the main plate 1131.

[0078] Note that because the slanted portions 1133b of the blades 1133 are slanted forward in the rotational direction, the cut-outs 1131b are disposed in the front portions in the rotational direction of the portions to which the blades 1133 of the main plate 1131 are attached (see Figs. 16 and 17).

(3) Special characteristics of the sirocco fan and impeller

[0079]

1. Here, because the blades 1133 are curved in a suitable position and slanted portions 1133b are provided in the blades 1133, the difference between the volume of air that flows in and out of the impeller at each position of the blades 1133 along the rotational direction O-O will be reduced, fan efficiency will be improved, and noise will be controlled.

In addition, providing the slanted portions 1133b on the blades 1133 and forming the cut-outs 1133b in the main plate 1131 will eliminate the interference (the main plate) from the projecting portions of the slanted portions 1133b. Because of this, as shown in Fig. 19, the impeller 1113 having the main plate 1131, the side plate 1132, and the blades 1133 can be unitarily formed from a synthetic resin material by means of a pair of molds 1060, 1070.

As shown in Fig. 19, the mold for forming the impeller 1113 from a synthetic resin is an upper mold 1060 and a lower mold 1070.

The upper mold 1060 includes projections 1061 that are inserted between the blades 1133. The projections 1061 include vertical surfaces 1061a that form the rear surfaces in the rotational direction of the main portions 1133a of the blades 1133, slanted surfaces 1061b that form the rear surfaces in the rotational direction of the slanted portions 1133b of the blades 1133, and horizontal surfaces 1061c that form the surfaces of the main plate 1131 adjacent to the blades 1133.

The lower mold 1070 includes projections 1071 that are removed downward from the cut-outs 1131b after formation. In addition, tip portions 1072 of the projections 1071 are tapered. This lower mold 1070 includes horizontal surfaces 1072a that form the side of the main plate 1131 that the blades 1133 are not attached to, vertical surfaces 1071a that form the front surfaces in the rotational direction of the main portions 1133a of the blades 1133, and slanted surfaces 1072a that form the front surfaces in the rotational direction of the slanted portions 1133b of the blades 1133. The vertical surfaces 1071a are on the projections 1071, and the slanted surfaces 1072a are parts of one side of the tip portions 1072 of the projections 1071.

This type of upper mold 1060 and lower mold 1070 forms the impeller 1113 that includes the slanted portions 1133b of the blades 1133, and after formation, both molds 1060, 1070 can be vertically pulled out. Thus, the blades 1133 and the impeller 1113 that include slanted portions 1133b that could not be unitarily formed in the prior art can now be formed by means of the lower mold 1070 that is inserted from the portions that become the cut-outs 1131b of the main plate 1131 and which forms in the inner surfaces of the slanted portions 1133b, and the upper mold 1060 that forms the outer surfaces of the slanted portions 1133b from the opposite sides.

In addition, although here the impeller 1113 can

be unitarily formed by the pair of molds 1060, 1070 by cutting out the main plate 1131 with respect to the projecting portions of the slanted portions 1133b of the blades 1133, cutting out the main plate 1131 has not been tried until now because it was felt that the capabilities of the sirocco fan would decline. However, after looking at the structure of the impeller from a variety of viewpoints, the inventors of the present invention recognized that even if the main plate 1131 is cut out as noted above with respect to the projecting portions of the slanted portions 1133b of the blades 1133, the capabilities of the sirocco fan (efficiency and noisiness) was not reduced and the capabilities of the sirocco fan were improved by providing the slanted portions 1133b. The impeller 1113 according to the present embodiment was created based on these insights, and with this impeller 1113, fan efficiency is improved and noise is controlled.

2. Here, as shown in Fig. 16, the cut-outs 1131b of the main plate 1131 that includes the projecting portions of the slanted portions 1133b of the blades 1133 reach the outer peripheral edge of the main plate 1131. Thus, the lower mold 1070 that is used for unitary formation has a structure that directly link the portions that cover the outer peripheral edge of the main plate 1131 and the projections 1071 that are inserted from the cut-outs 1131b of the main plate 1131, and this structure easily maintains the strength of the mold.

3. Here, the impeller 1113 has a structure in which slanted portions 1133b of the blades 1133 are slanted forward in the rotational direction, and the main plate 1131 is cut out with respect to the front of each blade 1133 in the rotational direction (see Fig. 18). By cutting out the main plate 1131 in this way, the impeller 1113 will not only maintain its capabilities with respect to situations in which there are not cut-outs 1131b, but will in fact improve its capabilities. This could not be imagined with a prior art impeller, but the improvements in the noise reduction capabilities are created because the turbulent vortices that are included in the air that collides with the main plate 1131 and flows toward the outer peripheral side escape from the cut-outs 1131b in the rotational axis O-O direction. In this way, the impeller 1113 of the present embodiment can provide improved capabilities due to the presence of the slanted portions 1133b of the blades 1133, and reduced noise due to the provision of the cut-outs 1131b in the main plate 1131.

(4) Modifications of the blades

[0080]

(A) Instead of the blades 1133 having the vertical cross-sectional shapes shown in Fig. 18, the blades 1233 having the vertical cross-sectional shapes shown in Fig. 20 can be employed to provide a low noise impeller capable of being unitarily formed with a synthetic resin.

As shown in Fig. 20, the entire portion of each of the plurality of blades 1233 that extend from the main plate 1131 are slanted forward in the rotational direction.

In addition, with the main plate 1131, projecting portions that are the entire portion of each of the blades 1233 that project toward the main plate 1131 along the rotational axis O-O are cut out therefrom. In this way, the cut-outs 1131c are formed in the main plate 1131 between adjacent blades 1233. These cut-outs 1131c are disposed in the front side in the rotational direction of portions to which the blades 1233 are attached to the main plate 1131 because the blades 1233 are slanted forward in the rotational direction.

(B) Instead of the blades 1133 having the vertical cross-sectional shapes shown in Fig. 18, blades 1333 having the vertical cross-sectional shapes shown in Fig. 21 can be employed to provide a low noise impeller capable of being unitarily formed with a synthetic resin.

As shown in Fig. 21, the plurality of blades 1333 that extend from the main plate 1131 are curved forward in the rotational direction from the base portions thereof that are connected to the main plate 1131, and then extend parallel to the rotational axis O-O. Then, near the side plate 1132, the blades 1333 again curve forward in the rotational direction, and the tips thereof are connected to the side plate 1132. Thus, as shown in Fig. 21, the blades 1333 include slanted portions 1333c that slant toward the main plate 1131, slanted portions 1333b that slant toward the side plate 1132, and main portions 1333a that link the slanted portions 1333b, 1333c.

In addition, with the main plate 1131, projecting portions that are slanted portions 1333b, 1333c of each of the blades 1333 that project toward the main plate 1131 along the rotational axis O-O are cut out therefrom. In this way, the cut-outs 1131 d are formed in the main plate 1131 between adjacent blades 1333. These cut-outs 1131d are disposed in the front side in the rotational direction of portions to which the blades 1333 are attached to the main plate 1131 because the blades 1333 are slanted forward in the rotational direction (see Fig. 21).

Here, because the plurality of slanted portions 1333b, 1333c are formed in the blades 1333, the volume of air that flows in and out at each position of the blades 1333 can be more finely adjusted, and the difference in the volume of air that flows in and out at each position of the blades 1333 can be further reduced.

(C) Instead of the blades 1133 having the vertical cross-sectional shapes shown in Fig. 18, blades

1433 having the vertical cross-sectional shapes shown in Fig. 22 can be employed.

As shown in Fig. 22, the plurality of blades 1433 that extend from the main plate 1131 along the rotational axis O-O are curved rearward in the rotational direction along their lengths, and the tips (other ends) of the blades 1433 are connected to the side plate 1132. Thus, the blades 1433 include a main portion 1433a on the main plate 1131 side, and a slanted portion 1433b on the side plate 1132 side.

In addition, with the main plate 1131, projecting portions that are the slanted portions 1433b of each of the blades 1433 that project toward the main plate 1131 along the rotational axis O-O are cut out therefrom. In this way, the cut-outs 1131e are formed in the main plate 1131 between adjacent blades 1433. These cut-outs 1131e are disposed in the rear side in the rotational direction of portions to which the blades 1433 are attached to the main plate 1131 because the slanted portions 1433b of the blades 1433 are slanted rearward in the rotational direction.

(D) Instead of the blades 1133 having the slanted portions 1133b shown in Fig. 17, blades 1533 having the slanted portions 1533b shown in Fig. 23 can be employed.

The plurality of blades 1533 that extend from the main plate 1131 are curved forward in the rotational direction along their lengths, and the tips (other ends) of the blades 1533 are connected to the side plate 1132. Thus, as shown in Fig. 23, the blades 1533 include a main portion 1533a on the main plate 1131 side, and a slanted portion 1533b on the side plate 1132 side. The slanted portions 1533b have a large degree of slant forward in the rotational direction on the inner peripheral sides thereof, and have a smaller degree of slant forward in the rotational direction on the outer peripheral sides thereof.

In addition, with the main plate 1131, projecting portions that are the slanted portions 1533b of each of the blades 1533 that project toward the main plate 1131 along the rotational axis O-O are cut out therefrom. In this way, the cut-outs 1131f are formed in the main plate 1131 between adjacent blades 1533. The cut-outs 1131f reach the outer peripheral edge of the main plate 1131, but the width of the portions thereof on the outer peripheral edge is small.

If the width of the portions of the cut-outs 1131f on the outer peripheral edge is small, it will be difficult to maintain the strength of the mold used to unitarily form the impeller from a synthetic resin, and thus in order to avoid this, the cut-outs 1131f may be made larger to form the cut-outs 1131g shown in Fig. 24. The widths in the rotational direction of the cut-outs 1131g formed in the main plate 1131 are equal to the degree to which the slanted portions 1533b of the blades 1533 project away from the rotational axis O-O and over the main plate 1131, and are shaped such that the width thereof on the outer peripheral edge is the same as that on the inner peripheral side thereof. If the cut-outs 1131g are formed, the portion of the mold that is inserted in the cut-outs 1131g will be solidly connected with the main portion of the mold that is positioned around the periphery of the main plate 1131, and thus the strength of the mold can be easily maintained.

(E) Instead of the blades 1133 having the slanted portions 1133b shown in Fig. 17, blades 1633 having the slanted portions 1633b shown in Fig. 25 can be employed.

[0081] The plurality of blades 1633 that extend from the main plate 1131 are curved forward in the rotational direction along their lengths, and the tips (other ends) of the blades 1533 are connected to the side plate 1132. Thus, as shown in Fig. 25, the blades 1633 include a main portion 1633a on the main plate 1131 side, and a slanted portion 1633b on the side plate 1132 side. The slanted portions 1633b have a small degree of slant forward in the rotational direction on the inner peripheral sides thereof, and have a larger degree of slant forward in the rotational direction on the outer peripheral sides thereof.

[0082] In addition, with the main plate 1131, projecting portions that are the slanted portions 1633b of each of the blades 1633 that project toward the main plate 1131 along the rotational axis O-O are cut out therefrom. In this way, the cut-outs 1131h are formed in the main plate 1131 between adjacent blades 1633.

[Fifth Embodiment]

[0083] In the fourth embodiment, the present invention was applied to a sirocco fan (one centrifugal fan), but the present invention may also be applied to another centrifugal fan, e.g., a turbo fan. Here, the projecting portions of the blades of the turbo fan (the entire portion of which are slanted) that project toward the main plate along from the rotational axis are cut out therefrom, and the main plate and the plurality of blades may be structured such that the impeller can be unitarily formed with a synthetic resin by only a pair of molds. Note that the shroud that corresponds to the side plate of the sirocco fan is mounted opposite the main plate and the plurality of blades unitarily formed with a synthetic resin.

[0084] Thus, if the present invention is applied to a conventional turbo fan in which each blade is molded with a slide mold, the cost of the mold can be reduced as well as the molding time, and thus a low cost turbo fan can be provided, because the main plate and the blades can be formed with only an upper and a lower mold.

[Other Embodiments]

[0085]

(A) With the impellers of the aforementioned embodiments, a portion of the inter-blade portions of the main plate are cut out. However, in situations in which there are no problems with strength and it is acceptable for the capabilities of the impeller to be slightly reduced, the entire inter-blade portion may be cut out, rather than just a portion thereof, in order to maximize space efficiency.
(B) The invention disclosed in the first to third embodiments is not limited to unitarily formed impellers made of a synthetic resin, but may be applied to impellers made of sheet metal.

INDUSTRIAL APPLICABILITY

[0086] If the present invention is used, the noise generated when the air flow is scooped out by the blades of the impeller of the multi-blade fan can be reduced.

Claims

1. An impeller (43, 213, 1113) of a multi-blade fan, comprising:

    a main plate (61, 231, 1131) that rotates about a rotational axis (O-O);
    a plurality of blades (33, 133, 1133-1333, 1533, 1633) that are annularly disposed about the rotational axis (O-O), one end of each of the plurality of blades (33, 133, 1133-1333, 1533, 1633) fixed to the main plate (61, 231, 1131); and
    an annular side plate (62, 132, 1132) that connects other ends of the plurality of blades (33, 133, 1133-1333, 1533, 1633);

    wherein inter-blade portions positioned between the plurality of blades (33, 133, 1133-1333, 1533, 1633) of the main plate (61, 231, 1131) are cut out at least in the front in the rotational direction of the blades (33, 133, 1133-1333, 1533, 1633).

2. The impeller (43, 213, 1113) of a multi-blade fan according to claim 1, wherein the side plate (62, 132, 1132) has an inner diameter that is larger than an outer diameter of the main plate (61, 231, 1131); and
    the inter-blade portions positioned between the plurality of blades (33, 133, 1133-1333, 1533, 1633) of the main plate (61, 231, 1131) are cut out larger than the outer dimensions of the blades (33, 133, 1133-1333, 1533, 1633).

3. The impeller (43, 213, 1113) for a multi-blade fan disclosed in claims 1 or 2, wherein the inter-blade portions are partially cut out in the circumferential direction.

4. The impeller (43, 213, 1113) for a multi-blade fan disclosed in any of claims 1 to 3, wherein the inter-blade portions are cut out from outer peripheral edges of the blades (33, 133, 1133-1333, 153 3, 1633) to inner peripheral edges thereof.

5. The impeller (1113) of a multi-blade fan set forth in any of claims 1 to 4, wherein the plurality of blades (1133-1333, 1533, 1633) include slanted portions (1133b-1333b, 1333c, 1533b, 1633b) that each slant forward in the rotational direction; and
    with the inter-blade portions, projecting portions of the slanted portions (1133b 1333b, 1333c, 1533b, 1633b) of the blades (1133, 1333, 1533, 1633) are cut out therefrom.

6. The impeller (1113) for a multi-blade fan disclosed in claim 5, wherein the entire portion of the plurality of blades (1233) is slanted.

7. A multi-blade fan, comprising:

    the impeller (43, 213, 1113) set forth in any of claims 1 to 6;
    a drive means (14) that rotates the main plate (61, 231, 1113); and
    a casing (11) that covers the impeller (43, 213, 1113), the casing (11) including an intake port (11b) that faces an opening in an inner peripheral side of the side plate (62, 132, 1132) and a discharge port (11a) that is provided on an outer peripheral side of the impeller (43, 213, 1113) and which blows air in a direction approximately perpendicular to the rotational axis (O-O).

Fig. 1

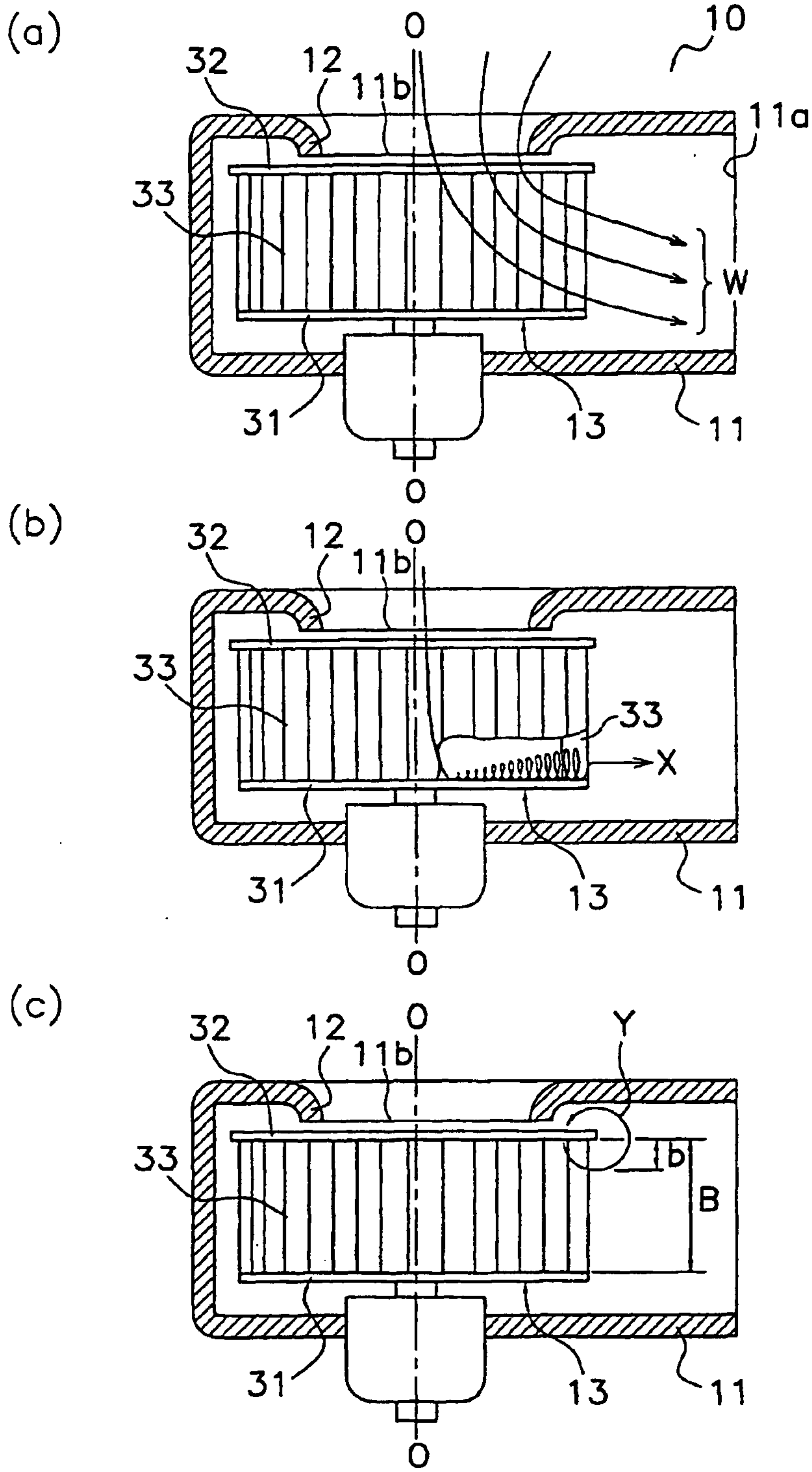

(a)
O
10
32
12
11b
11a
33
W
31
13
11
O
(b)
32
12
11b
O
33
33
X
31
13
11
O
(c)
32
12
O
11b
Y
b
33
B
31
13
11
O

Fig. 2

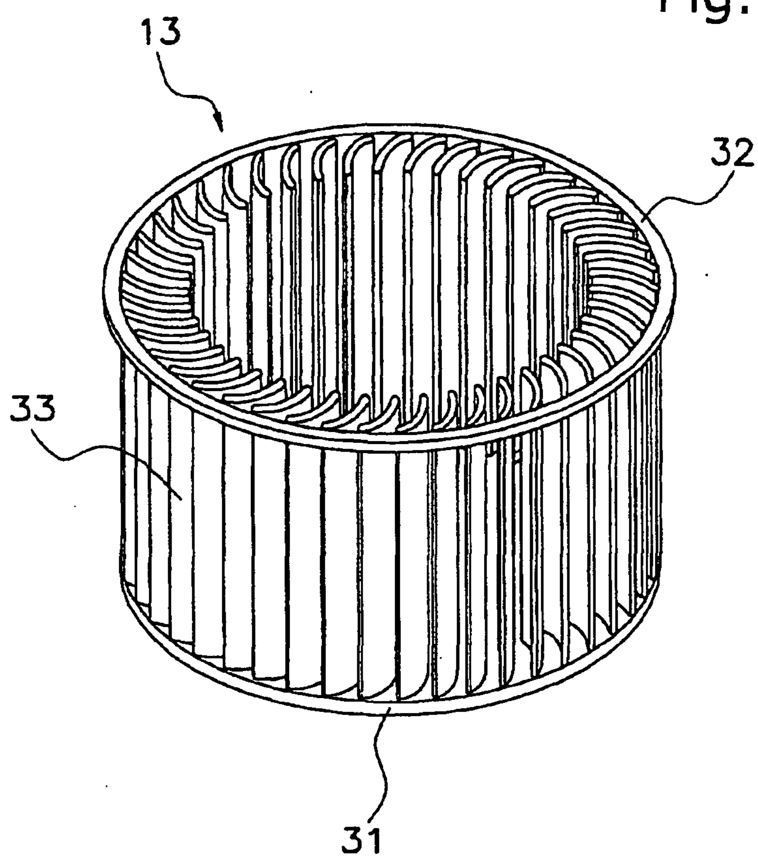


Fig. 3

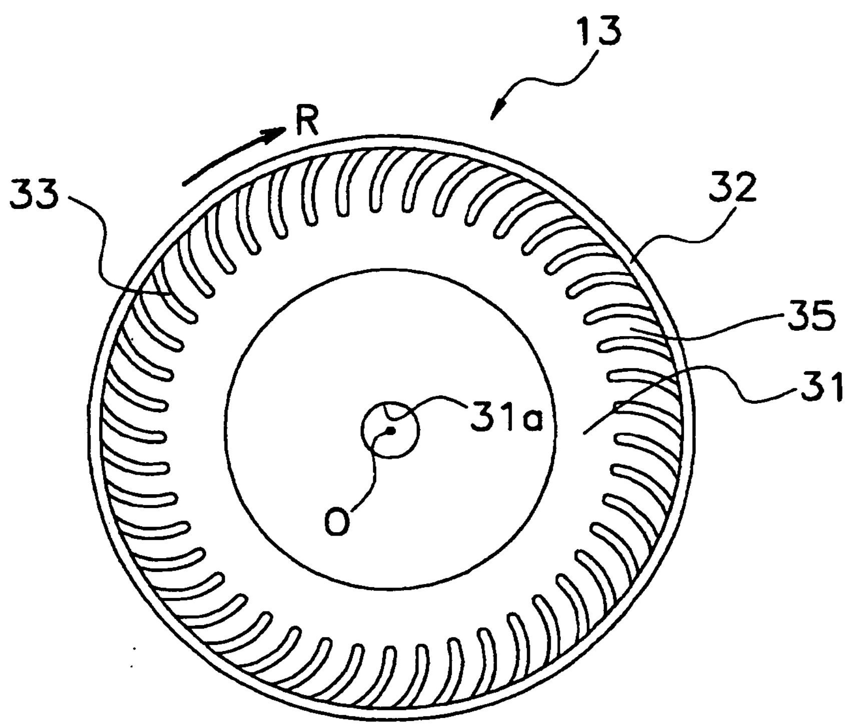


Fig. 4

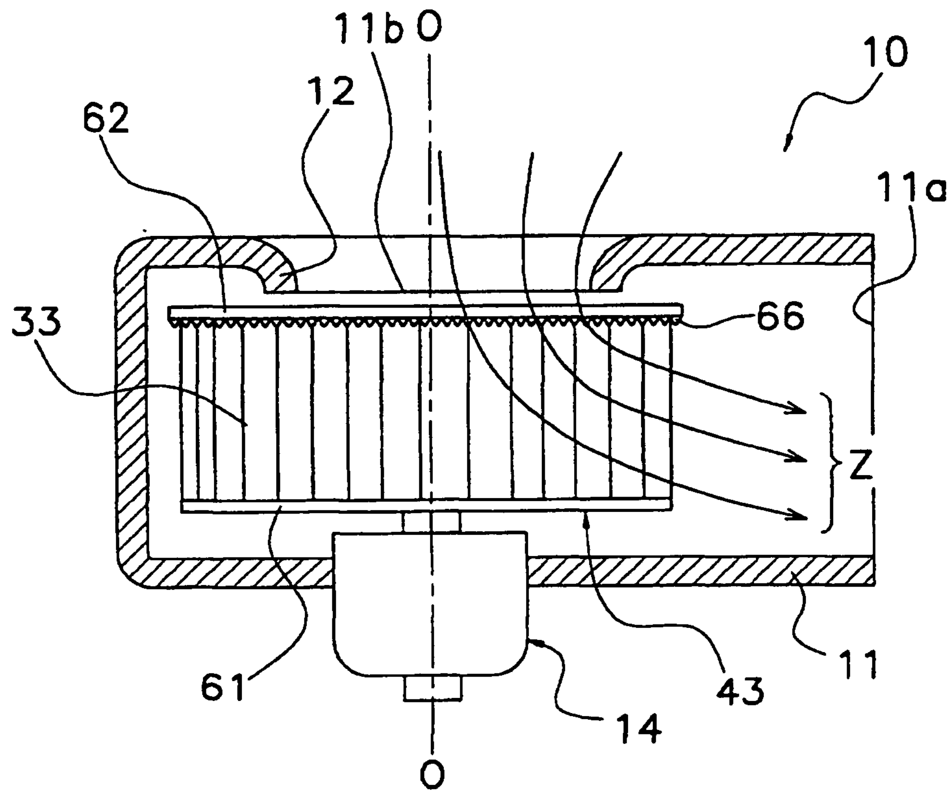


Fig. 5

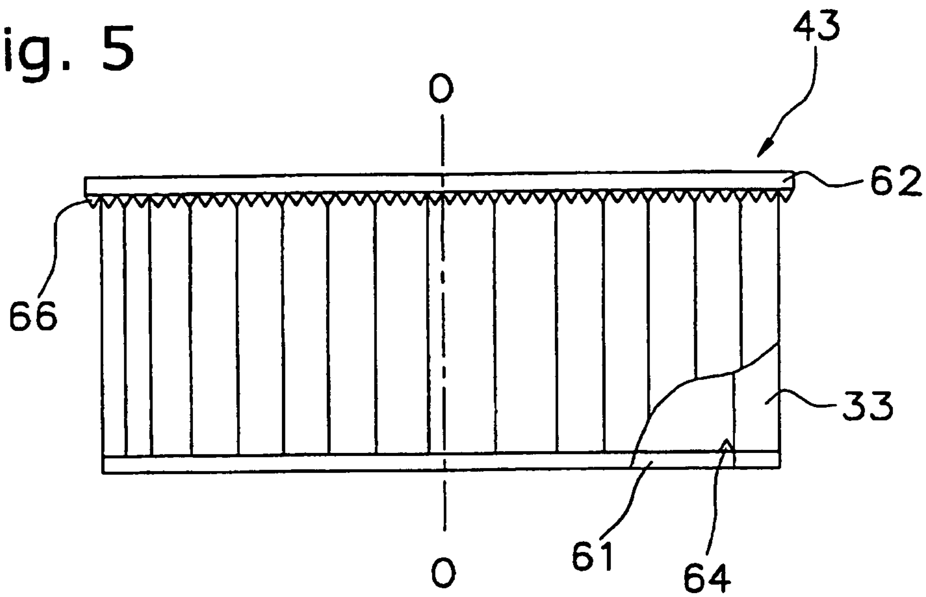


Fig. 6

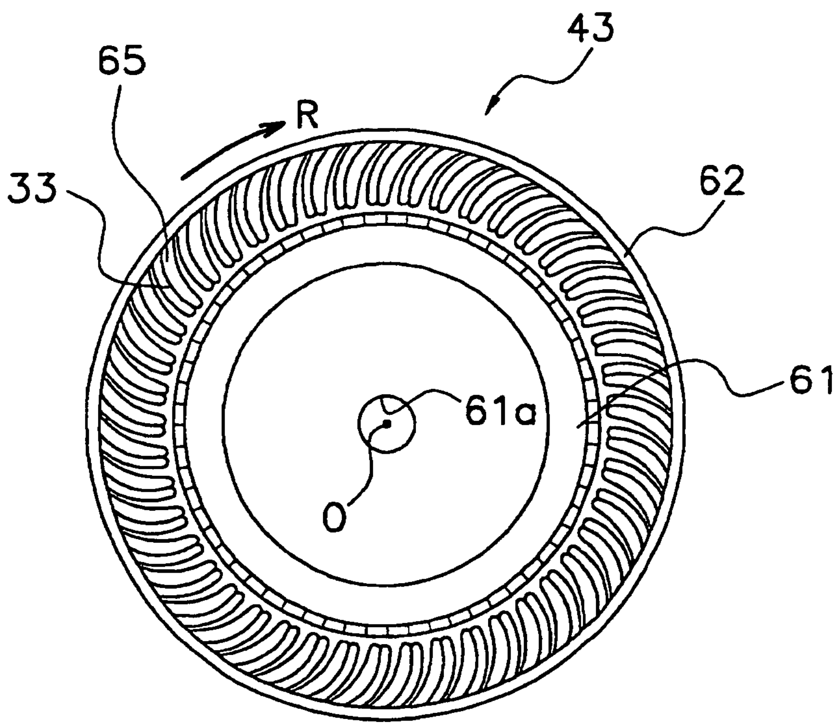
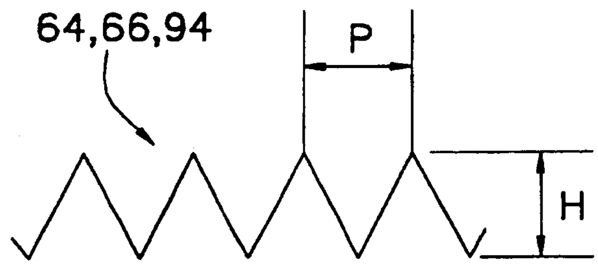


Fig. 7

(a)



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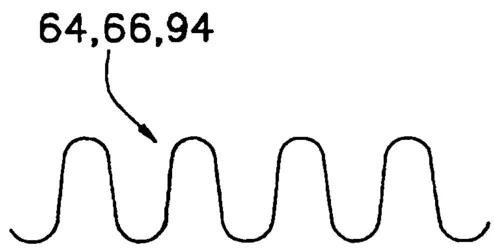


(c)

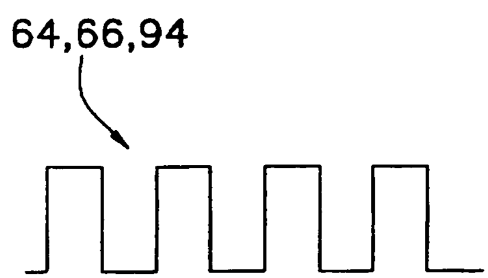
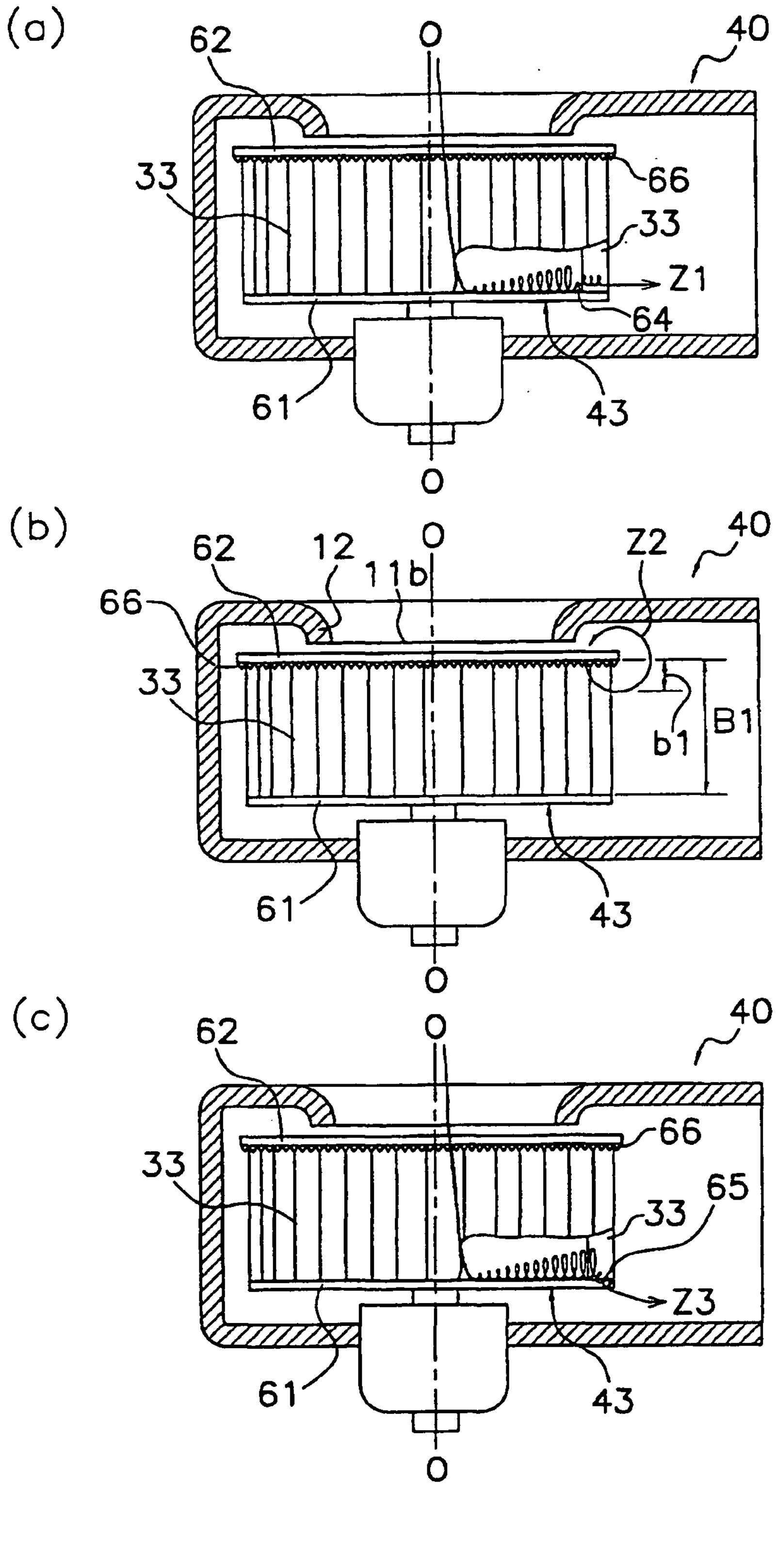


Fig. 8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62
O
40
33
66
33
Z1
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61
43
O
(b)
62
12
11b
O
Z2
40
66
33
b1
B1
61
43
O
(c)
62
O
40
66
33
65
33
Z3
61
43
O

Fig. 9

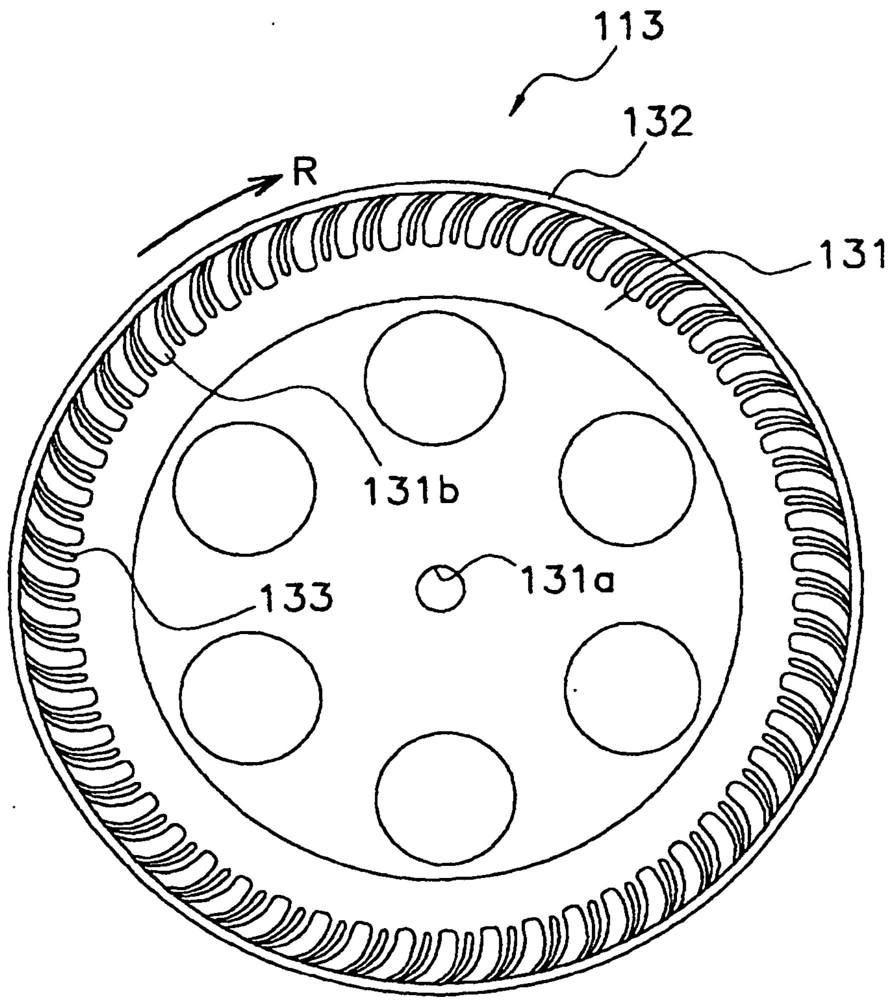
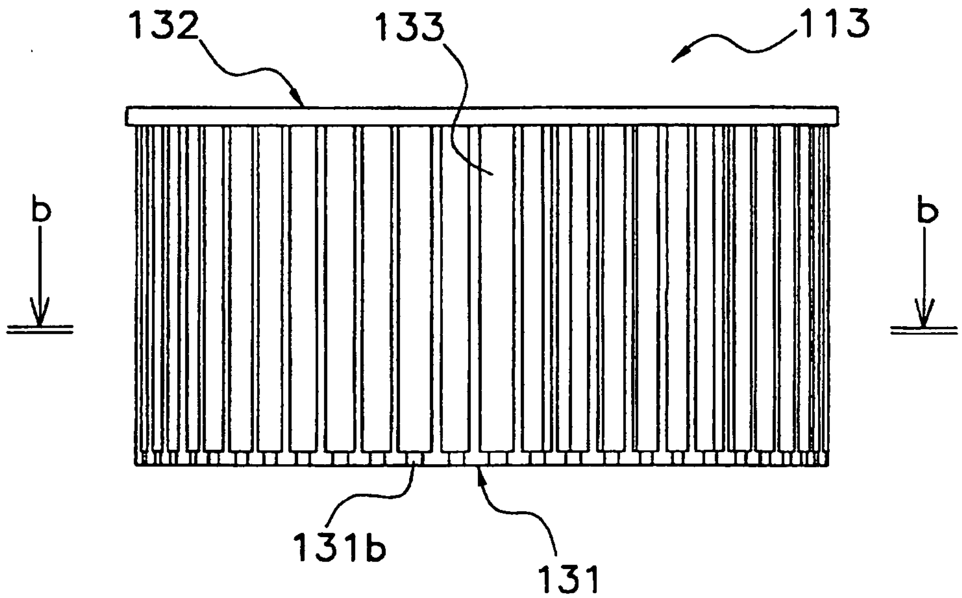


Fig. 10

(a)



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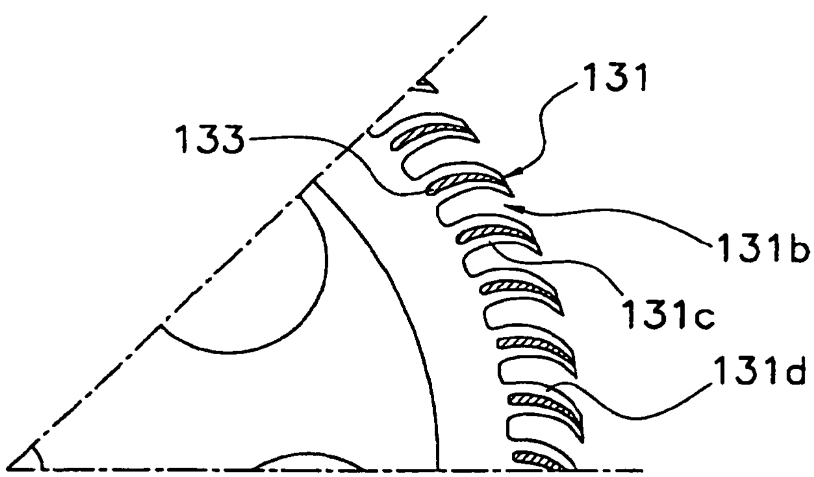


Fig. 11

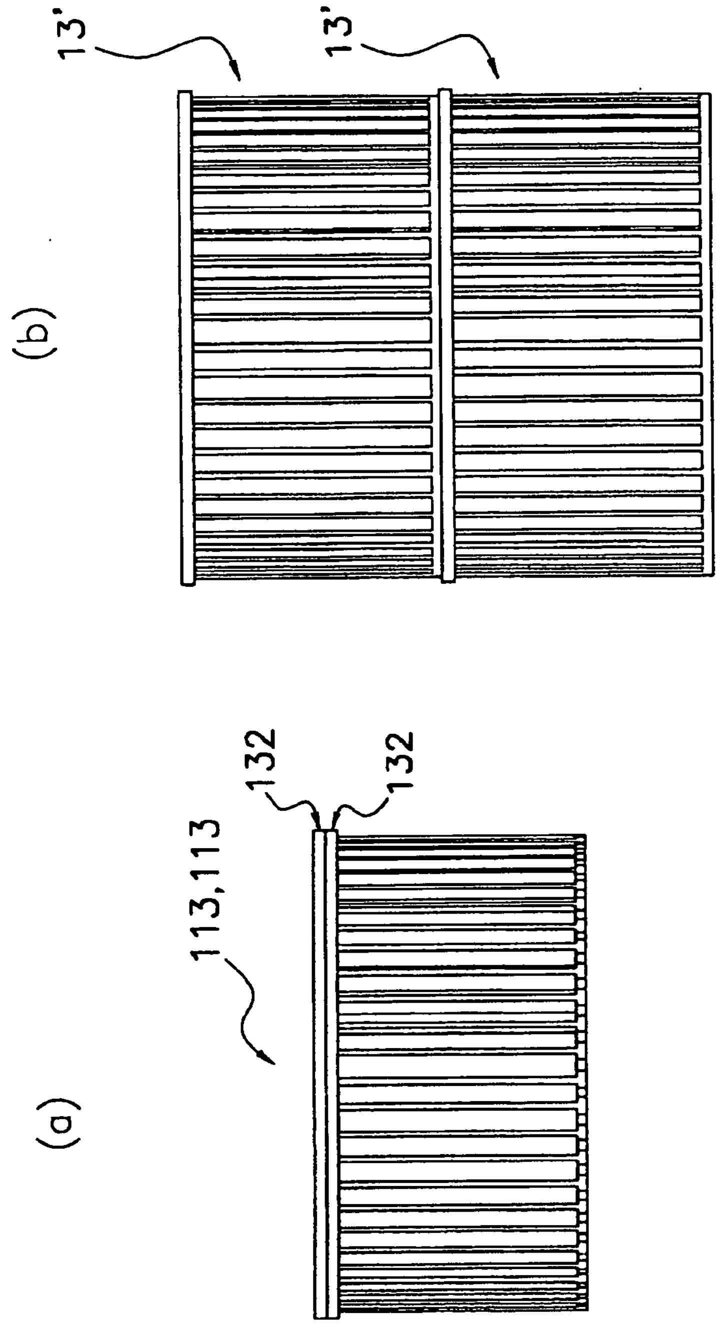


Fig. 12

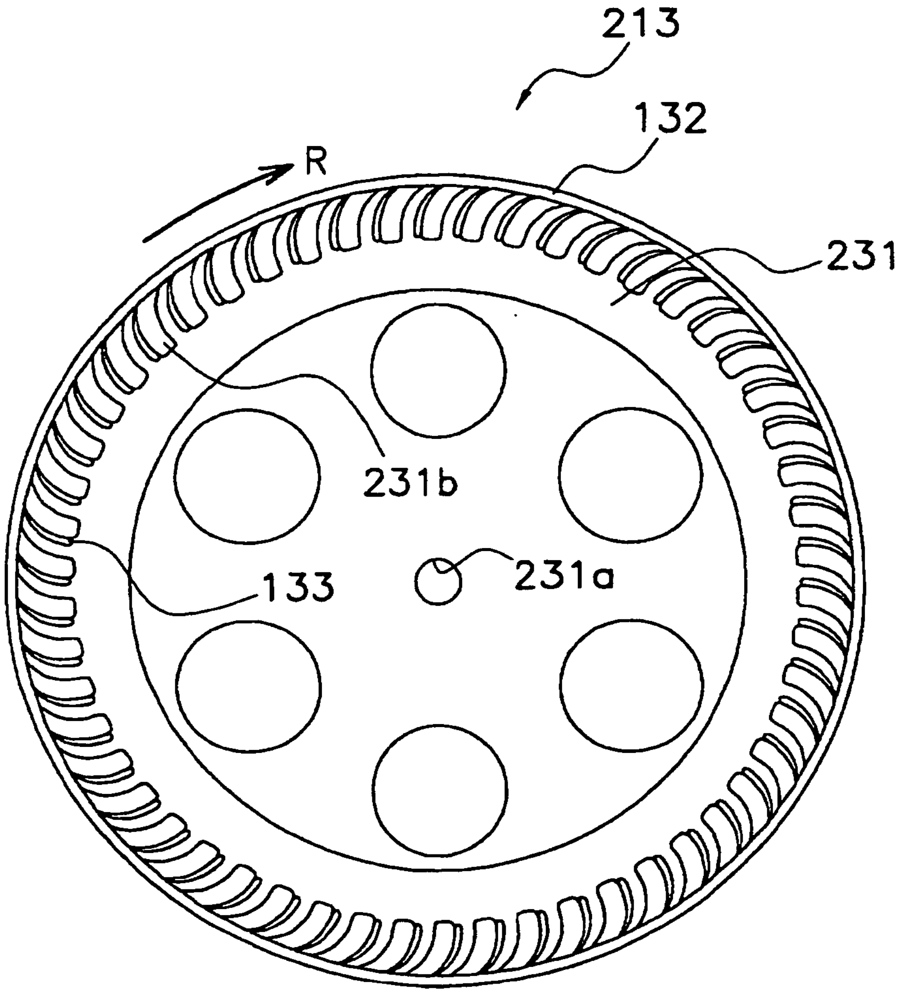


Fig. 13

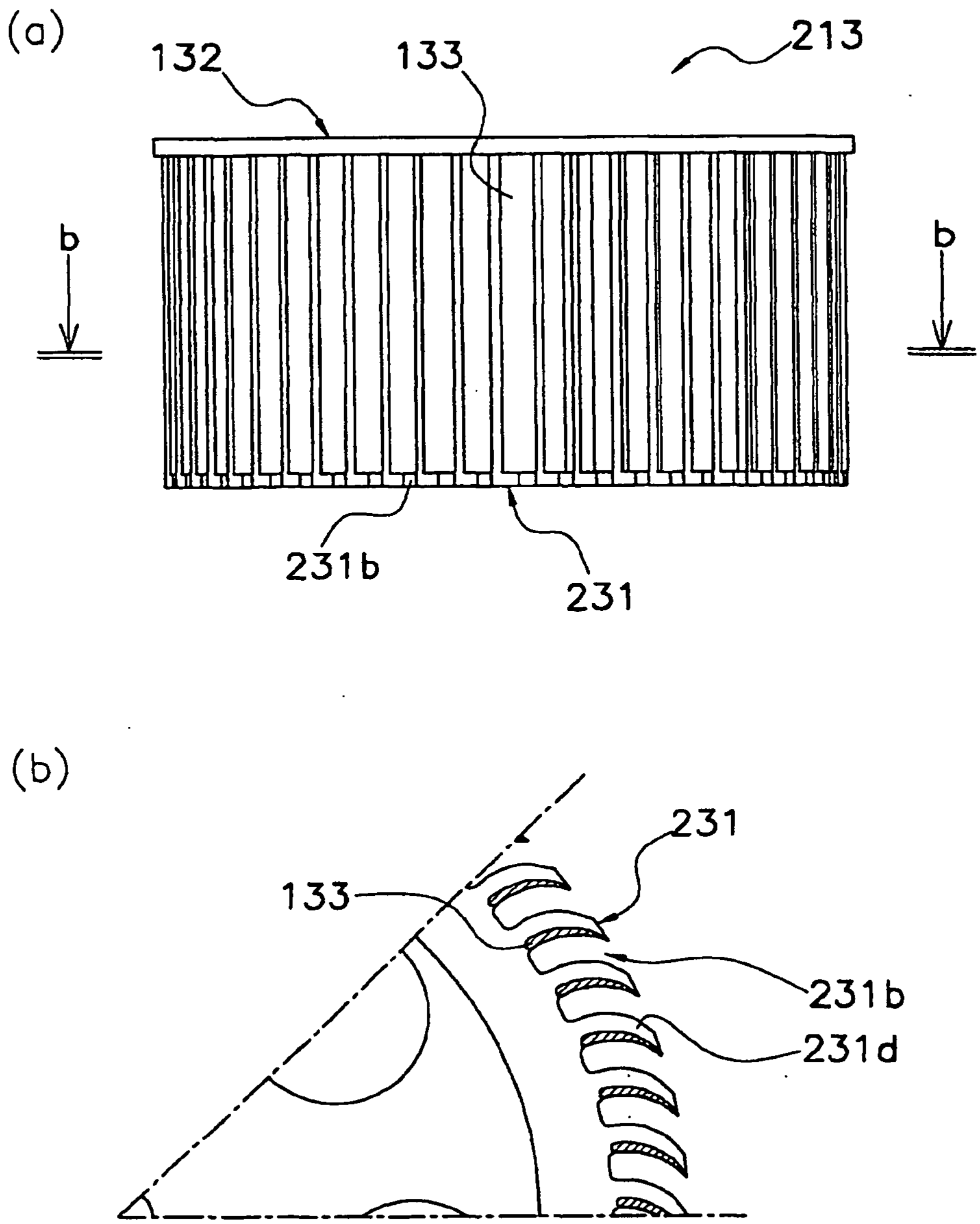


Fig. 14

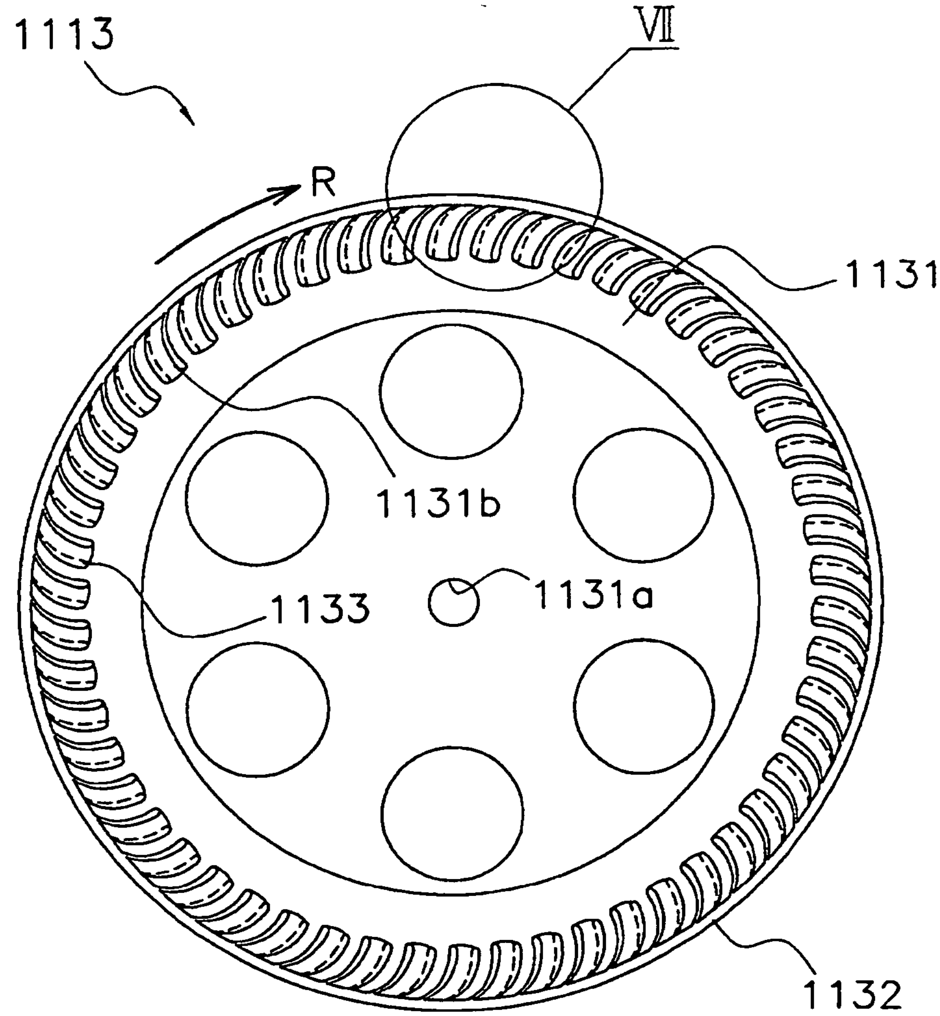


Fig. 15

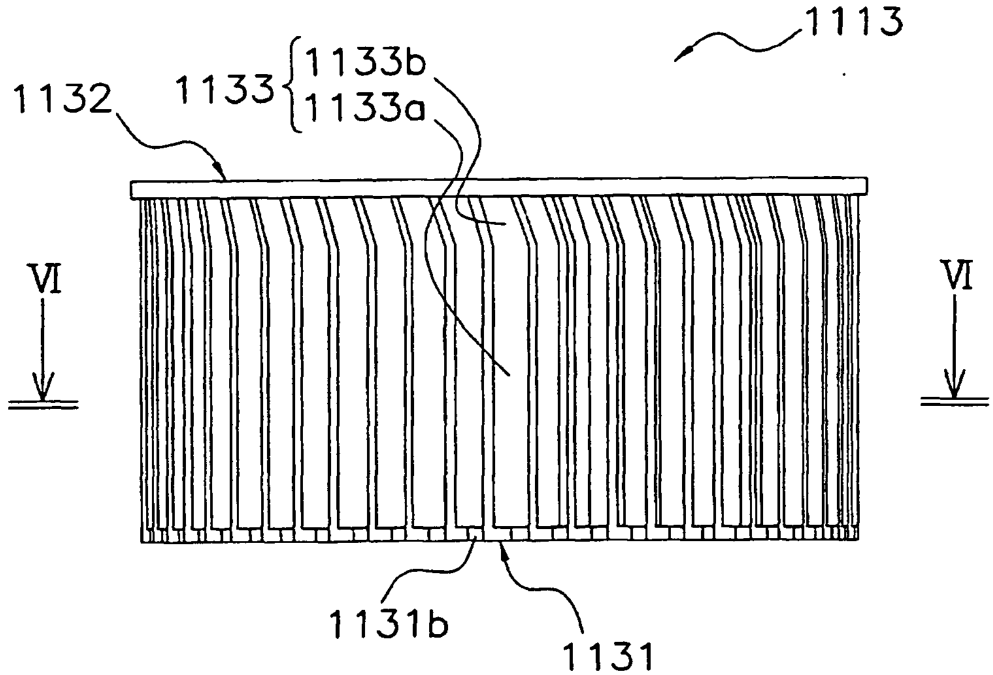


Fig. 16

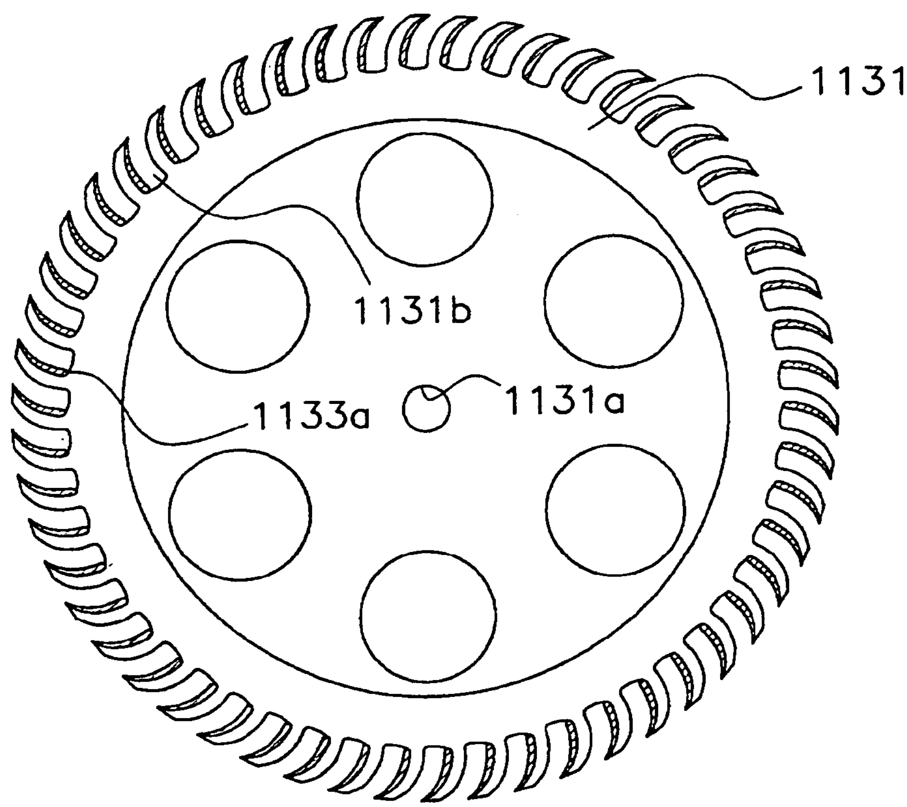


Fig. 17

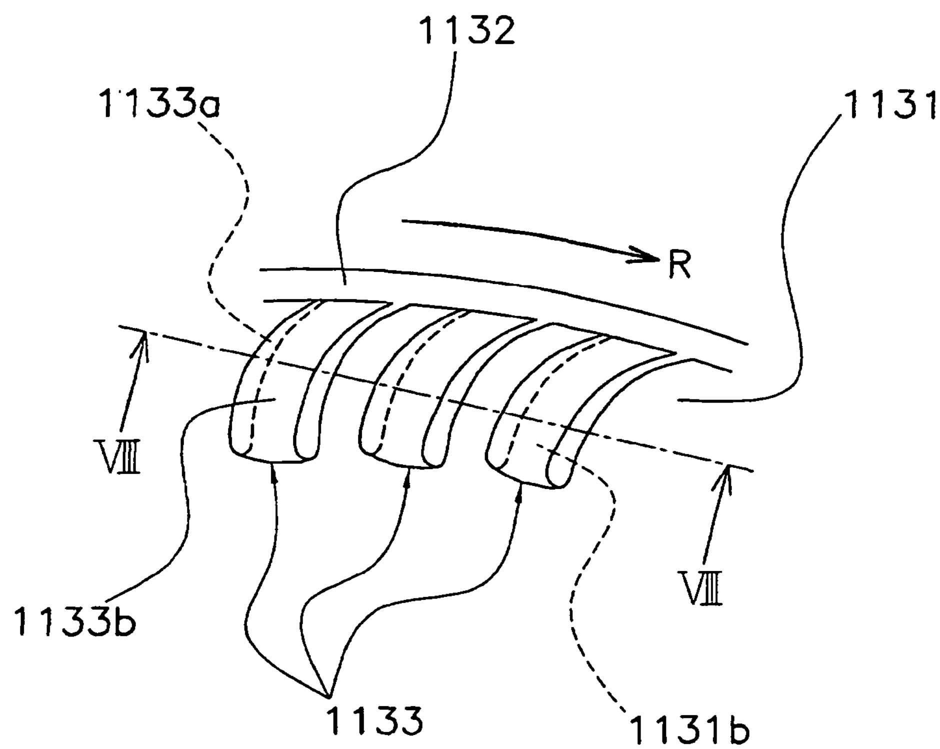


Fig. 18

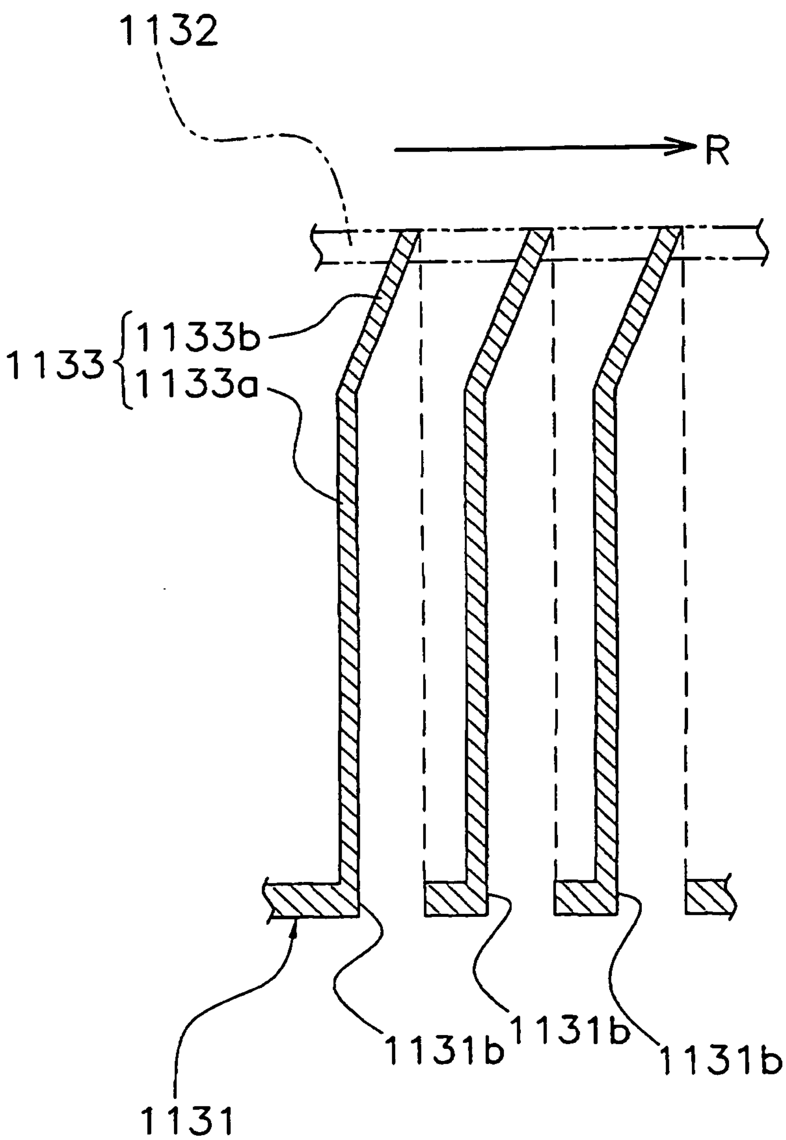
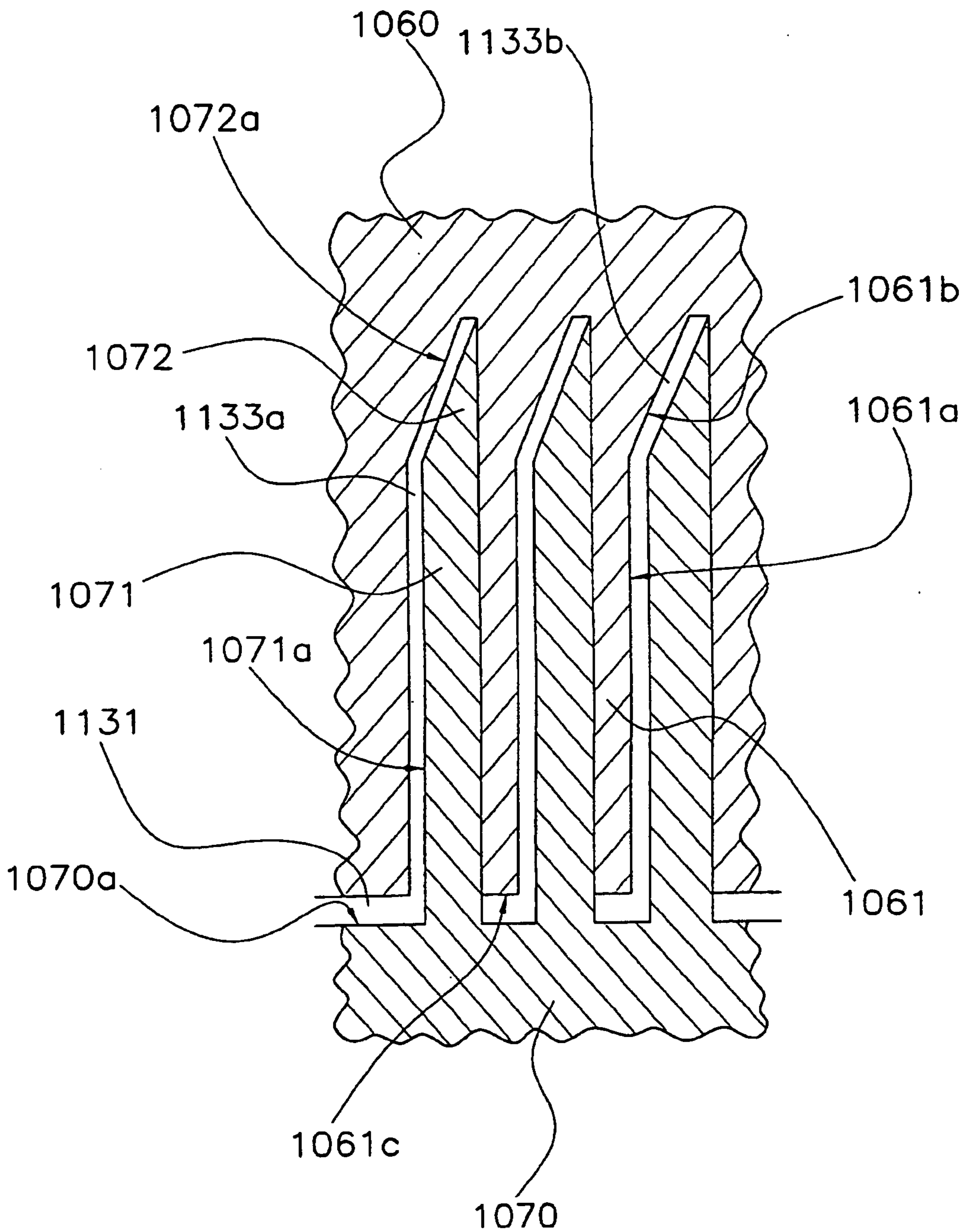


Fig. 19


1060
1133b
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1061b
1072
1133a
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1071a
1131
1070a
1061
1061c
1070

Fig. 20

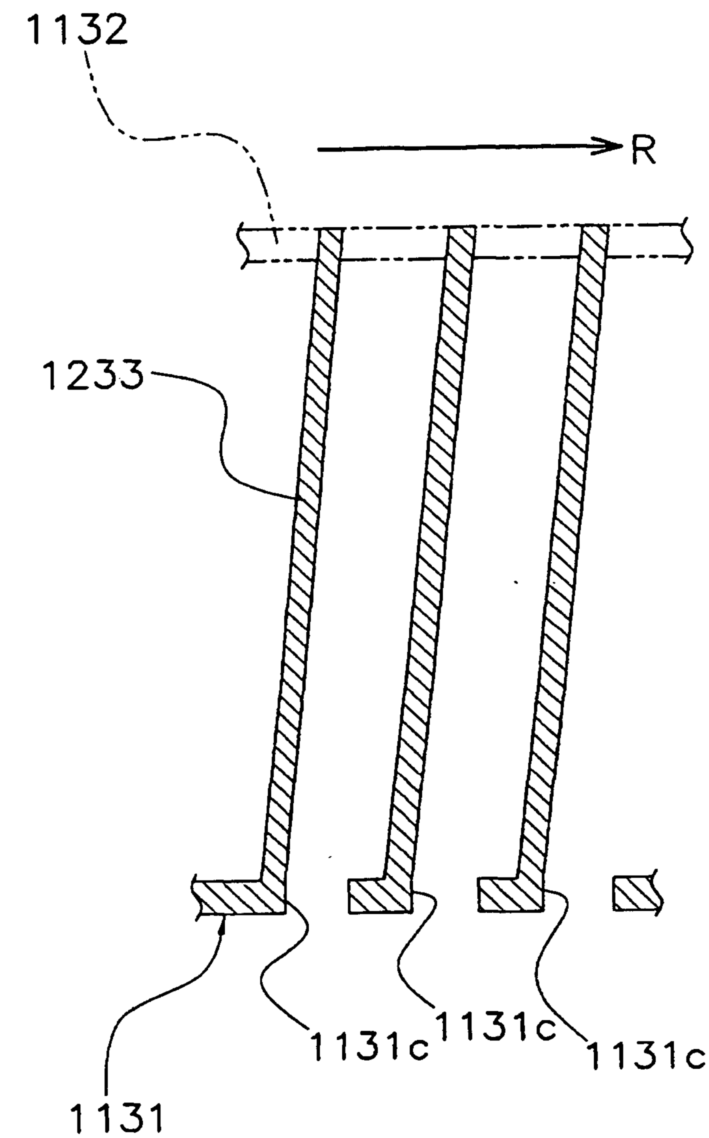


Fig. 21

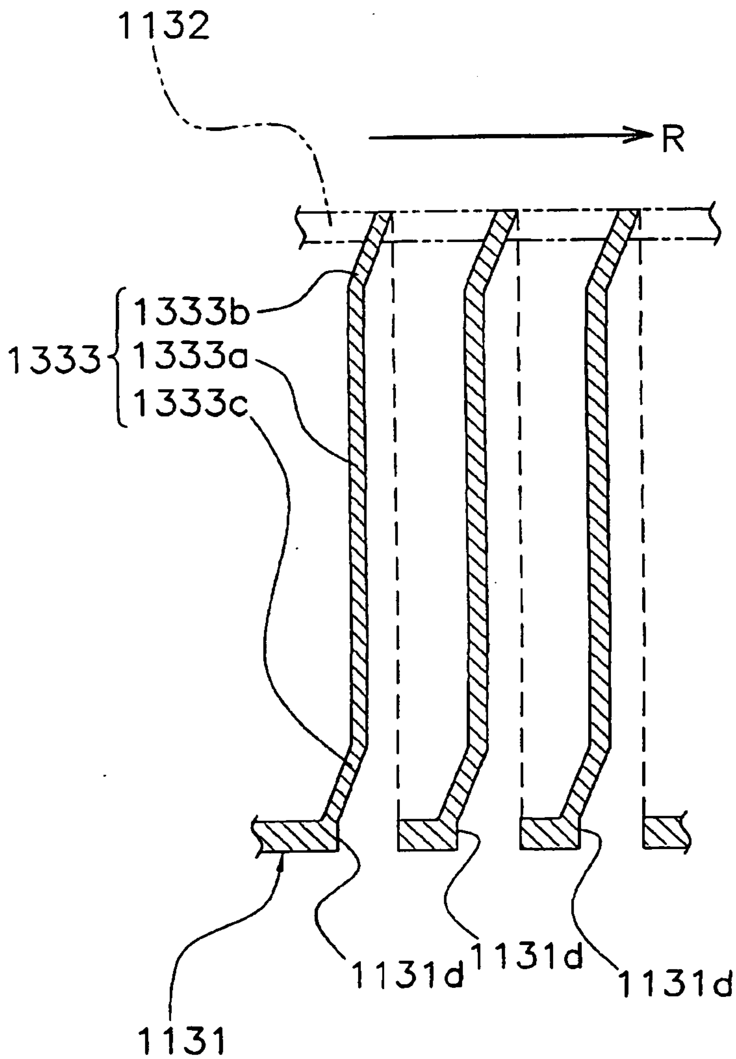


Fig. 22

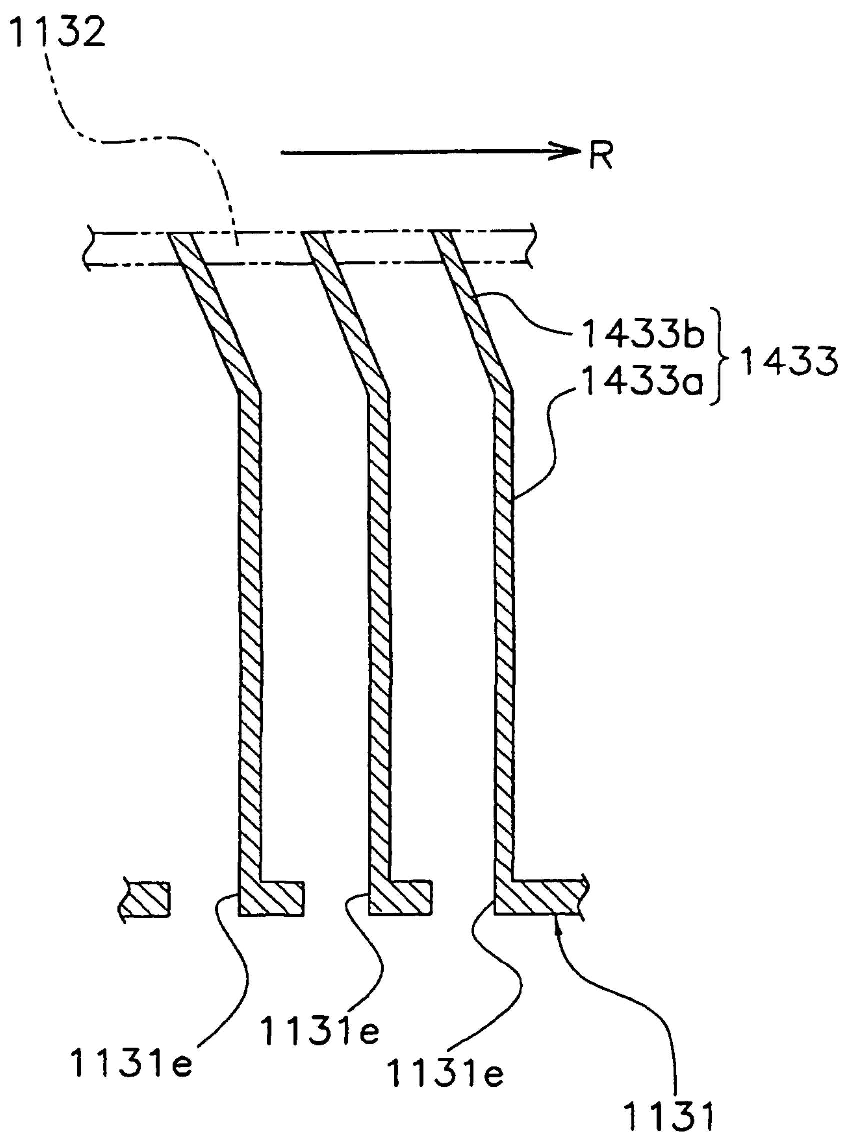


Fig. 23

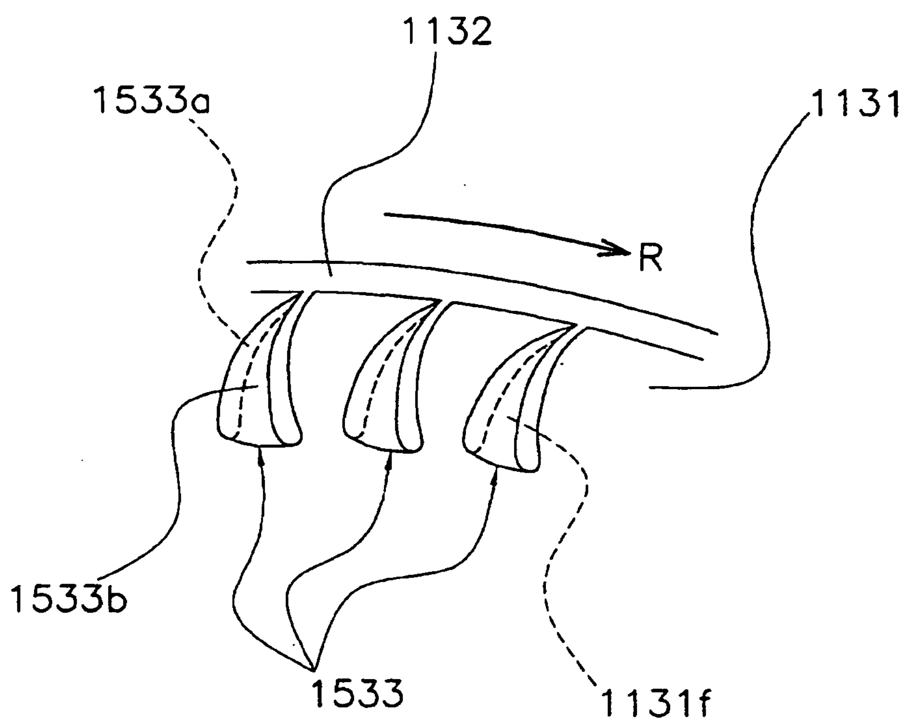


Fig. 24

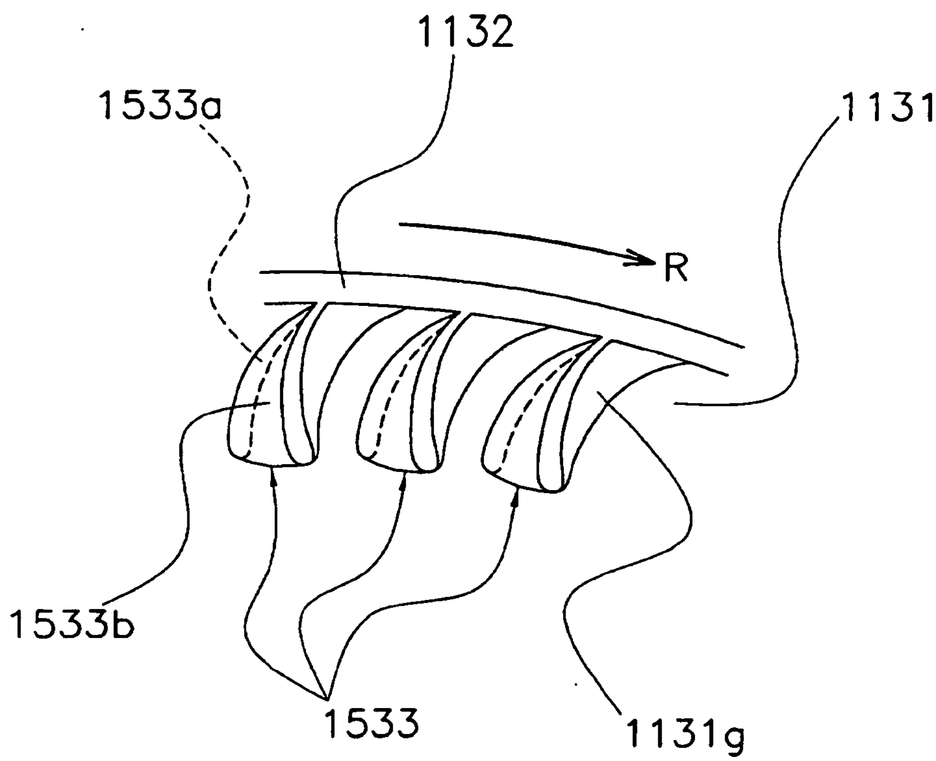
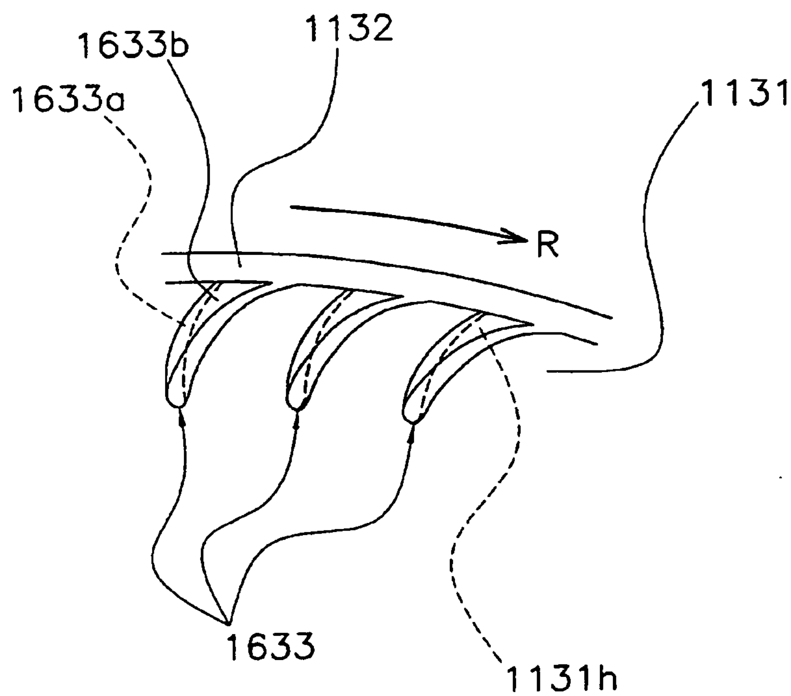


Fig. 25



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP02/05883

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl[7] F04D29/28, F04D29/44, F04D29/66

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
Int.Cl[7] F04D29/28, F04D29/44, F04D29/66

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho	1922-1996	Toroku Jitsuyo Shinan Koho	1994-2002
Kokai Jitsuyo Shinan Koho	1971-2002	Jitsuyo Shinan Toroku Koho	1996-2002

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 7-63195 A (Matsushita Electric Industrial Co., Ltd.), 07 March, 1995 (07.03.95), Full text; Figs. 1 to 4 (Family: none)	1-7
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 117198/1988 (Laid-open No. 39595/1990) (Matsushita Refrigeration Co.), 16 March, 1990 (16.03.90), Full text; Figs. 1 to 5 (Family: none)	1-7

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
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"&" document member of the same patent family

Date of the actual completion of the international search 28 August, 2002 (28.08.02)	Date of mailing of the international search report 10 September, 2002 (10.09.02)
Name and mailing address of the ISA/ Japanese Patent Office	Authorized officer
Facsimile No.	Telephone No.

Form PCT/ISA/210 (second sheet) (July 1998)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP02/05883

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 117196/1988 (Laid-open No. 39593/1990) (Matsushita Refrigeration Co.), 16 March, 1990 (16.03.90), Full text; Figs. 1 to 6 (Family: none)	1-7

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